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DIVISION OF WATERSHED MANAGEMENT RESEARCH

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Semiannual Report

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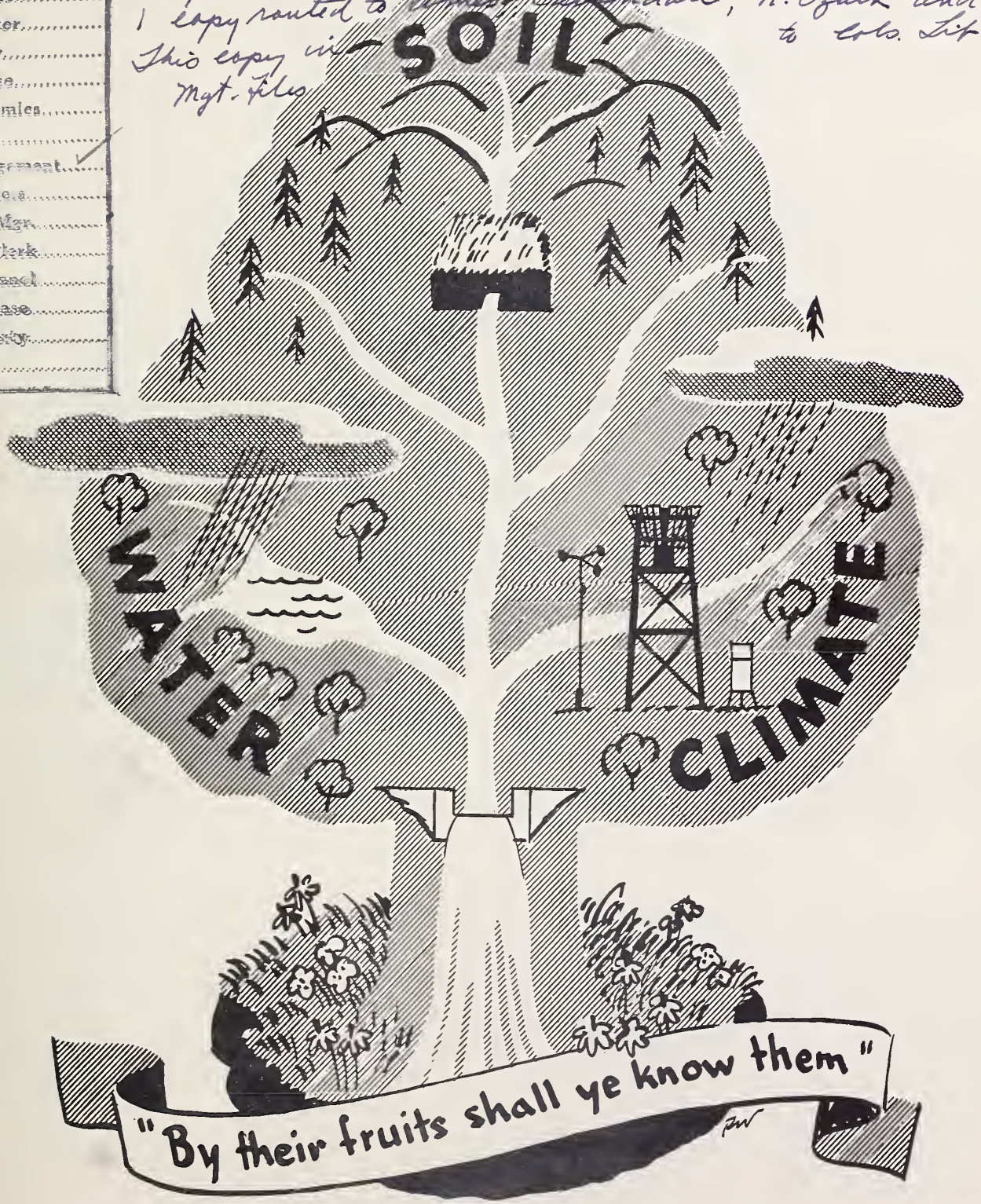

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

October 1953 — March 1954

5748

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SEMIANNUAL REPORT
Division of Watershed Management Research
October 1953 - March 1954

Washington Office Activities

As of March 15, 1954 the official name of our Division is Watershed Management Research. This designation brings our name in line with those of the other R Divisions, and fits more closely the terminology which we have applied to explain the meaning of our activities to persons unfamiliar with the term "forest and range influences."

An item of interest to Watershed Management Research personnel—and which will undoubtedly involve them directly or indirectly—is the probable restoration by Congress of funds for a Department of Agriculture Yearbook on Water in 1955.

The revised WMR filing scheme has been transmitted to all stations and is awaiting field comments. This scheme is geared to that used in transmitting project status reports to Agricultural Research Service.

The color slide file continues to build up; there are now some 335 slides, with the result that most of the gaps are now filled. However additional slides on phases of the work not previously covered (as indicated by your own contributions) will continue to be welcome.

Hydrologic Subcommittee - In response to a proposal by the Forest Service representative, the Hydrologic and Sedimentation Subcommittees of FIARBC have jointly agreed to sponsor a series of talks by qualified representatives of member agencies on research activities in fields pertinent to the work of these committees. First on the schedule—at the May meeting—is a talk by Mr. Storey on watershed research by the Forest Service.

Also in the mill is the preparation of a supplementary bibliography on hydrology and sedimentation (covering period 1951-54, inclusive) to be completed in 1955. A contract has been let with American Geophysical Union to handle the mechanics and details of this project.

Now under way is a reorganization of the agricultural hydrology program in the Branch of Soil and Water Conservation headed by Bob Salter. A chief of the Section of Agricultural Hydrology is scheduled to report soon for duty. He is likely to be W. C. Ackerman, now with TVA Hydraulic Data Division under Albert S. Fry. This SWCR Branch of ARS received a sizable increase in the House so that it could undertake an expanded program commensurate with the needs for scientific information in this field.

(Over)

Ecology of Africa - In January the research staff heard an illuminating talk by Dr. John Phillips, ecologist of Africa, on the ecological approach to control of the tsetse fly in connection with the British government's land conversion project (for groundnut culture) on 3,000 square miles in the Volta River watershed. Direct efforts to bulldoze a way without an adequate foundation of research through the problem of large-scale conversion completely failed, leading to serious erosion, overgrazing, and human impoverishment. The experiment turned out disastrously because the "practical" administrators ignored the warnings of ecologists. This experience indicated the utter failure of "one-shot" attempts to clear and utilize wildlands for agricultural purposes. Altogether, it cost the British government 37 million pounds to realize that an ecological approach was needed to furnish sound guidelines.

Dr. Phillips said that a million pounds for surveys and studies in advance of the direct action program would have prevented this disaster. He said also that human relations are an integral part of ecology and cannot safely be overlooked. In the new effort, no actual developmental work is to be started until exhaustive ecological investigations are completed.

One of the most serious mistakes was that the time element was ignored; the developers pushed too fast. In land clearing, etc., machinery has its place, along with hand labor but it must be of the right kind and properly used. Otherwise it will only serve to ruin the land and the people. The program must be adapted to the environment, including the human aspects--standard methods don't work. For example, the technique of land clearing used in the abortive attempt was useless, and adequate answers are still lacking.

The question of controlled burning has proved to be a very touchy one, especially in the higher, drier parts of Africa. Opposite views have been held by various technical groups. Some Scotch botanists are unalterably opposed to burning. The best answer found so far has been to burn at the proper time and place according to the climatic, soil, and vegetative needs and in accordance with the purposes of burning, i.e., whether for grazing improvements or other aspects. No set rules can be developed for all situations.

Have You Seen? (1) Sport Fishing Institute Bulletin No. 26, January 1954, entitled "Highlights of 1953." See especially pages 1-2 which discuss the relations of fishing to watershed management. (2) "Mechanical Soil Stabilization" by Leo J. Ritter, Jr., in Public Works for March 1954, Vol. 85, No. 3. The discussion on the factors involved in stabilizing soils of road surfaces and shoulders by mechanical means may have value in studies of soil compaction and frost. Our interests lie primarily in avoiding compaction and in maintaining or improving soil drainage, so that studies which seek the opposite objectives may provide some useful clues to conditions which favor compaction or loss of permeability under grazing use, logging, etc. (3) Some references on influences of trees, shrubs on noises, odors:

Köck, G. Über die Rauchgasfiltrationswirkung eines Fichtenbestandes. Phytopathol. Zeitschrift. 7(3): 255-258. 1934. A screen of spruce trees for filtering industrial smoke and gases.

Katz, M. Sulfur dioxide in the atmosphere and its relation to plant life. Indus. & Engin. Chem. 41: 2450-2465. Ref. Nov. 1949. (Canadian investigation. Very thorough on tree relationships.)

Tribus, L.L. Odors and their travel habits. Amer. Soc. Civil Engin. Trans. 85: 378-429. 1922. (No specific info. on trees and veg.)

Kaye, G.W.C. Sound and noise. Sci. Prog. /London/ 30(119): 385-401. 1936. Includes noise abatement, and the role of hedges and trees in reflecting high-pitched components of noise but allowing lower notes to pass around or through. (Like the pollution articles, this one emphasizes the importance of atmospheric condition, terrain, and buildings, rather than vegetation.)

Kisser, J. Baum und Strauch im Herzen der Grossstadt. Natur u. Land 33(1): 8-11. 1946.

Eyring, C.F. Jungle acoustics. Acoustical Soc. of Amer. J. 18(2): 257-270. Oct. 1946. (Includes measurement of sound penetration through forested terrain in Panama.)

The Federal Register, Vol. 19, No. 54, March 19, 1954, lists Executive Order 10521 on the administration of scientific research in the Federal Government. Section 8 requires that major research equipment and facilities be shared among research agencies and that no Federal agencies "shall" procure new major equipment or facilities except after ascertaining the availability of such items from other agencies. In line with this provision the thought occurs that we might want to include in our Semiannual Progress Reports a list of instruments and equipment surplus to each station's needs and also a similar list of items needed by given stations. (We understand that some research centers do not see the surplus property lists received at station headquarters from other stations.) The lists would refer only to special equipment or instruments used in watershed management research. We believe this plan may facilitate better use of equipment and possibly result in money savings.

Discussion

Some Observations on Soil Freezing - How fire accentuates soil freezing was clearly evidenced by examination of a burned sedge grass field on Rock Creek watershed in the Piedmont section of Maryland January 31, 1954. This field was abandoned from cropping about 15 years ago and reverted to a complete and thick cover of sedge grass together with a scattering of Virginia pine. The period of abandonment was not long enough to permit development of an observable humus layer (H)(Manor loam-micaceous phase). However the soil was completely protected from direct rainfall impact both by the grass and by the litter from the pines. Slopes are gentle, ranging from practically level to about 10 percent in the vicinity of Coquelin Run, a tributary of Rock Creek.

In December 1953, following a period of several weeks without rain, the area was burned over. As is usual with ground fires, the burn was spotty, leaving unburned patches within the area. Some of the pines were killed, but most were only scorched near the base and the leaves on the lower portions of the crowns killed. Six weeks after the burn, on January 31, 1954, I revisited the area to determine the type and incidence of frost. Temperatures had been below freezing for several days, so that evidences of such frost could be expected.

The unburned patches both within the burn and outside its boundary exhibited no evidences of firm frost either beneath the pine litter or sedge grass. The ground was soft and moist—but not wet—and examination of the soil showed only occasional particles of granular frost. The burned portions on the other hand uniformly exhibited a continuous layer of concrete frost varying from one-half inch to 2½ inches below the surface of the soil.

Incidentally, observations of the effects of a light spring burn in an old-growth hardwood area with a heavy litter cover and well-developed humus horizon (H) in another portion of Rock Creek watershed dramatically revealed the insulating value of the litter (L) layer. These observations were made on February 15, 1948, one day after a flood occasioned by rapidly melting snow and ice. This fire consumed only the litter layer (the accumulation of 3-5 years) but did not disturb the fermentation (F) layer beneath. Nevertheless, firm frost was consistently encountered wherever the litter had been destroyed, whereas only granular, discontinuous frost was observed within and around the edges of the fire where the litter had not been burned.

-- Bernard Frank

SEMIANNUAL REPORT -- OCTOBER 1953-MARCH 1954

Forest Influences Division

California Forest and Range Experiment Station

GENERAL

In the April-September 1953 semiannual report we noted evidence of increasing interest in watershed management in the West. During the past six months more evidence has accumulated.

First, the disastrous mountain fires in southern California, continuing far past the usual end of the fire season, were followed by several storms which released extremely damaging floods from some of the burned lands. The public had been kept aware of the flood hazards below the burned areas, so that many communities were prepared when the floods came. Nonetheless, the extensive damage done by the January floods made it appear fortunate that the storms producing them were far lighter than some experienced in these mountains during the past twenty years. Following the floods, the Los Angeles County Forest and Watershed Protective and Rehabilitation Commission was formed to plan for more effective protection of mountain lands against the ravages of fire. The California Station was asked to submit to this Commission recommendations for research in fire control and watershed protection. The Influences Division submitted a plan for research in first-aid treatment of burned land, research designed to seek methods of treatment which would be more immediately effective than the sowing of mustard and ryegrass. The Commission met late in March, but we have not yet heard what action was taken on the research proposals submitted by the Station.

Second, Colman was invited to discuss the needs for watershed management research at a joint meeting of the State Forestry and Water Resources Boards in January. This meeting was the first at which the two Boards had met together. It was called for the specific purpose of considering the interests of the two Boards in watershed management. The consensus was that meetings of the same kind should be held at regular intervals in the future.

Third, the California Station and the University of California were requested to submit to the State Department of Natural Resources proposals for research projects in the field of resource conservation. A considerable sum of money will soon come to the State from impounded Tidelands Oil royalties, and the Department hopes that some of this money will be made available for research in the natural resources field. Two research proposals were submitted by the Division of Forest Influences: one for study of snow-pack management in the Sierra Nevada, the other for study of the hydrologic aspects of brushland conversion on foothill lands.

Personnel

O. C. Olson transferred on November 16 to the vegetation-soil mapping project being conducted in northern California by the Forest Experiment Station in cooperation with the State of California.

H. W. Anderson took charge of the soil movement study in Los Angeles River watershed on November 29 in place of Olson.

George L. Downing, a member of the Forest Experiment Station's new Division of Forest Insect Investigations, established his southern California headquarters at the San Dimas Research Center in Glendora early in March.

PUBLICATIONS

Manuscripts submitted for publication

"Effects of the Forest Floor on Disposition of Rainfall in Pine Stands" by P. B. Rowe has been accepted for publication in the Journal of Forestry. This paper was discussed in the last semiannual report.

"Erosion in the San Gabriel Mountains of California" by J. D. Sinclair, and "Suspended Sediment Discharge as Related to Streamflow, Soils, Topography, and Land Use" by H. W. Anderson are scheduled for April publication in the Transactions of the American Geophysical Union.

At the request of the chairman of the Committee on Runoff, American Geophysical Union, Anderson briefly summarized current "Runoff" research by the Forest Service, largely as reported in recent quarterly and semiannual reports of the Influences Division. Similarly, for the Committee on Land Erosion, Anderson and Sinclair prepared a report of research on land erosion in California.

"Fire-Flood Sequences on the San Dimas Experimental Forest" by the staff of the San Dimas Experimental Forest will be published soon as Technical Paper #6 of the Forest Experiment Station. This manuscript has been developed from a report prepared in February concerning the recent fire and floods in Wolfskill Canyon, described later in this report. The effects of a fire that burned into the San Dimas drainage in 1938 are also discussed.

Manuscripts in Preparation

"Rainfall Sampling on Rugged Terrain" by E. L. Hamilton, planned for publication as a U.S.D.A. Technical Bulletin, has been completed and submitted to the Forest Service editor.

"Development of Vegetation after Fire in the Chamise Chaparral of Southern California" by Horton and Kraebel is ready for presentation to Ecological Monographs.

"Root Systems of Some Chaparral Plants in Southern California" by Hellmers, Juhren, Horton, and O'Keefe is nearly ready for review by the Station editor. This paper, written for publication in Ecology, describes the root systems of 18 species common in the chaparral and discusses the place of the various types of root systems in watershed management.

Findings of the Fire Case History Study have been written up in first draft by Gleason for publication under the tentative title "Brushland Burning and Soil Erosion in Northern California."

Other papers being reviewed or revised within the Division are:

"Temperature Requirements for Germination in Relation to Wild-Land Seeding" by Ashby and Hellmers.

"Use of Laboratory Techniques for Evaluating the Growth Characteristics of Grasses" by Ashby and Hellmers.

"Growth Characteristics of Grasses as Affected by Temperature and Photoperiod" by Ashby and Hellmers.

"Soil Fertility: A Watershed Management Problem in the San Gabriel Mountains of California" by Hellmers, Bonner, (of Cal. Tech.), and Kelleher.

CURRENT RESEARCH

WATERSHED DAMAGE FROM LOGGING

A field examination of a logging area in the redwood region was made in January by Kraebel, with McRo.ey and Meadowcraft of the Regional office. Watershed damages of large dimensions were observed to have resulted from logging in very steep terrain during the heavy autumn rains. The principal damages were in the form of massive earth slides into creeks and roads, and the choking of streams with tangles of slash and broken logs. By comparison, the usual gullying of skidways and road-slopes appeared minor, although in other parts of the state they would be regarded as serious.

A peculiarity of the mountainous part of the redwood region, which receives upwards of 50 inches of rain annually and has little or no frost, is the luxuriance of undergrowth in the forest and the rapid development of new tree growth in openings. Consequently, the scars of logging and erosion are quickly covered and become invisible within

a few years. A slope, for example, that was logged, burned, and heavily eroded in 1937, was densely covered with redwood, Douglas fir, and undergrowth in 1954. Examples of this kind tend to belittle the damages and even to erase the memory of them with the passage of a few years. These "deceptions" of nature, however, can not undo the damage that actually occurred. To the practiced eye, evidences remain in the mudbars, cutbanks and stagnant pools of streams, and in the log tangles bedded in them. The possible impairment of site quality on reclothed but once eroded slopes is still a matter of conjecture.

SAN DIMAS EXPERIMENTAL FOREST

Fire and Flood

Wildfires burned-over more than 170,000 acres of brush- and forest-covered lands in southern California during 1953, the greatest loss of watershed cover since 1919. The fire season was aggravated by lack of fall rains and by abnormal conditions of temperature, relative humidity, and wind. Even after the rains started in January, warm dry periods alternated so with wet periods that the fire control personnel were at times on standby into March.

The climax of the fire season was reached during a violent wind storm on December 27, 1953. At that time the Barrett fire of December 12 broke out of control and spread rapidly, reaching finally into two watersheds of the San Dimas Experimental Forest, both within the major San Dimas Canyon drainage. In watershed I (Wolfskill Canyon, 1,525 acres) 483 acres were burned, 278 acres severely and 205 acres partially. In watershed II (Fern Canyon, 1,370 acres) the 46 acres burned were in the nature of a slop-over, with 10 acres severely burned and 36 acres partially burned. The severe burning occurred chiefly in chamise and scrub oak.

The fire was still being patrolled when a series of rain storms occurred. The first, on January 11, 1954, brought 0.95 inch of precipitation at the Wolfskill intensity rain gage, elevation 3,600 feet. The second storm, January 17-20, totaled 6.36 inches and the third storm, January 23-25, 6.55 inches. Rainfall rates for the three storms, in order, were 0.23, 0.64, and 0.79 inches per hour for a 1-hour period and 0.48, 1.32, and 2.52 inches per hour for 5 minutes' duration.

Rainfall quantities and rates in the second and third postfire storms resulted in high and abnormal runoff at the Wolfskill stream-gaging station. Streamflow at the gaging station was at the rate of 0.11 c.f.s. before rain started on January 17. By midnight of the 18th, after about 2 inches of rain, the flow had increased to 1.8 c.f.s., and by 0240 on the 19th it had gone to 43 c.f.s. bulked by mud, rocks, and fire debris. Fluctuating streamflow of this character continued for 2 hours when suddenly a crest 6-1/2 feet in depth passed through the

10-foot San Dimas flume. This would be a flow of 1,025 c.f.s. and was composed of water, mud, rocks, and logs, Flow persisted at 700 c.f.s. for 10 minutes and then dropped to 200 c.f.s. A 4-foot boulder was deposited in the throat of the 3-foot San Dimas flume and many boulders were left in the approach to the large flume. Flows of similar nature but of smaller size occurred during the January 23-25 storm.

Fair weather prevailed for about 3 weeks thereafter, and streamflow at the Wolfskill station dropped to 0.54 c.f.s. A storm of 4 inches on February 13-14, less intense than those of January, produced a peak of 36 c.f.s. The weather turned fair again until March 16 when a series of light rains totaling 6.30 inches raised the base flow to about 1 c.f.s.

A study was made to determine the influence of the partial denudation of watershed I on peak flows. Records from unburned watershed III (upper East Fork of San Dimas Canyon, 1,370 acres) were used as a basis of comparison. Watershed III is reasonably comparable to watershed I in several respects, including aspect and elevation, and in vegetative cover before the 1953 fire. Peak flows from watersheds I and III, under both dry and wet watershed conditions, produced by storms closely similar in size and other characteristics, were compared before and after the fire. The results indicate that in January peak flows from watershed I, 32 percent burned, were 67.7 times as great as normal, under dry soil conditions, and 15.6 times as great under wet soil conditions.

It was estimated that on the average more than 0.6 inch of ash, soil, gravel, and decomposed rock was removed from the side slopes by sheet and rill erosion. In addition, it was estimated that more than 3,000 cubic yards of material were removed from the burned area by bank cutting and scouring in the steep headwater channels. These estimates indicate that more than 42,000 cubic yards of soil and other debris were washed from the 484 acres of burned area in watershed I. This represents an erosion rate of 55,600 cubic yards per square mile.

The normal erosion rate for San Dimas Canyon, to which Wolfskill is a tributary, has been computed from sedimentation measurements in the flood control reservoir near the mouth of San Dimas Canyon. This erosion rate is about 2,000 cubic yards per square mile per year. The erosion rate for the two storms following the fire, then, is more than 28 times the average annual rate for unburned watersheds in this area.

At the present time with streamflow of about 1 c.f.s., sand, silt, and gravel are moving through the watershed I streamgaging station at the rate of 30 cubic yards a day. This represents erosion at the rate of 20,000 cubic yards per square mile per year.

The streamflow reactions described above are not unusual in southern California. Rain delivered at high rates on fire-damaged watersheds usually produces large peak flows. These flows bulked with debris

can cause severe damage if reservoirs or downstream improvements lie in their path, as is frequently the case. The Monrovia Peak fire, which burned 14,135 acres above Monrovia, Arcadia, and Sierra Madre in December 1953, was followed by severe flooding of these cities in January. Unburned areas nearby produced no floods during the January storms.

Rainfall

Rainfall at Tanbark Flat during the first 6 months, ending March 31, of the hydrologic year 1953-54, amounted to 24.70 inches which is slightly over the 25-year average of 24.31 inches for the same period. Although current rainfall is about average there was a marked deficiency during the fall of 1953. Rainfall at Tanbark Flat from October 1 to December 31 averages 8.82 inches, but the total during this 3-month period last year was only 1.85 inches. This deficiency was a major factor contributing to the severe and prolonged fire season in southern California.

Streamflow

Streamflow from all watersheds within the San Dimas Forest has been low to moderate during storms, with the exception of the debris-laden flood flows from watershed I (Wolfskill Canyon) described earlier in this report.

During October 1953 Rowe, Reimann, and Sinclair prepared a work plan for the analysis of streamflow records from the San Dimas Experimental Forest watersheds. The primary purpose of this analysis is to establish relations in streamflow between watersheds in order to determine, within known limits of accuracy, flows from one watershed based upon records of flows from other watersheds. The work is aimed at (1) providing a basis for reducing streamflow record collection, and (2) standardizing the watersheds under present conditions in order to evaluate the effects of experimental treatments or chance changes in watershed conditions upon storm discharge and water yields. Analysis of data has been started.

Lysimeters

Satisfactory calibration curves have been developed for all fiberglas soil moisture units installed in the confined lysimeters planted to oak and pine. Tables for the computation of soil moisture percents have been prepared. Routine computation of soil moisture percents from the accumulated soil-unit readings will start in the near future.

Survival and growth of the vegetation planted in the lysimeters were measured in February. The dry winter of 1952-53 followed by the dry fall of 1953 caused a prolonged period of drought. With the

exception of the hoaryleaf ceanothus, all planted vegetation withstood this drought. There were, however, many deaths of ceanothus.

The response of Coulter pine to fluctuations in available soil moisture during a period of six years is shown in the following table:

Hydrologic year	Moisture available for plant growth 1/	Subsequent growth 2/ Average length	
		New shoots	Needles
	Inches		
1947-48	12.7	7.3	--
1948-49	14.4	6.1	5.0
1949-50	17.5	12.2	5.5
1950-51	9.4	4.6	3.0
1951-52	25.6	8.5	8.5
1952-53	12.6	12.0	3.5

1/ Precipitation minus runoff and seepage.
2/ For example, growth in 1948 for the hydrologic year 1947-48.

Needle length seems to be more closely correlated to yearly rainfall than shoot growth. This is probably because shoot growth occurs first, followed by elongation of the needles.

Shoot growth may perhaps be related to the vigor of the plant as determined by conditions prevailing during the previous growing season. For instance, the average shoot growth of 12.0 inches in 1953 following the dry winter of 1952-53 may have been due to the excellent moisture conditions prevailing during the 1952 growing season. Needle growth was abruptly terminated in 1953 when moisture was no longer available. The growth of both shoots and needles in 1953 is in sharp contrast to their development in 1952.

Rainfall Disposition

Tanbark Plots--The invasion of roots from the brush plots into the adjacent grass plots has been recognized as a factor that may influence soil moisture in the grass plots. Soil depths up to 17 feet make construction of a barrier between the brush and grass plots impractical. Present plans call for the installation of another set of

plots nearby in similar brush cover and underlain with deep soils. After the new plots have been compared with the original brush plots and relations between them established, the brush on the older plots will be converted to grass or other plants that will not extend their roots into the present grass plots. A location has been chosen for the new brush-covered plots.

A comparison of water use (year-long and seasonal) by native brush, annual grass, and Coulter pine at Tanbark Flat appears in the 1953 Annual Report of the California Station.

LOS ANGELES RIVER WATERSHED

Soil Studies

First measurements of the quantities of soil moving into the troughs at the five study sites are now summarized and some analyses of the data have been made.

The rates of soil delivery into the troughs during three periods--corresponding approximately to the summer dry season, fall wetting season, and winter wet season--are summarized below together with some characteristics of each study area.

Soil delivery and site characteristics	Site name				
	Lower Brown	Upper Brown	Falls	Singing Springs No. 1	Singing Springs No. 2
	-Tons/Acre/Month-				
Soil delivery					
Dry season July 16-Nov.14, 1953	0.525	0.038	0.075	0.007	0.012
Wetting season Nov.15, 1953-Jan.11, 1954	.123	.048	.063	.011	.020
Wet season Jan.12-March 1, 1954	1.540	0.038	0.057	0.033	0.016
Relative rate of soil delivery	47	3	5	1	1
Site characteristics					
Trough length, feet	68	273	431	291	200
Area above trough, acres	0.72	0.82	1.27	1.44	1.64
Exposure	South	South	North	South	North
Geologically rejuvenated	Yes	No	Yes	No	No

These first results indicate the principal source areas of soil movement to be the rejuvenated sites. The Lower Brown rejuvenated site was the chief source of soil movement, producing some 16 times as much as the comparabel Upper Brown nonrejuvenated site. Soil movement during the dry season was caused largely by debris sliding and creep. The movement at the rejuvenated sites decreased with the first fall rains as the moisture settled the soil and gave it some degree of cohesion. The winter rains, moderate this year, increased rates of movement at some sites. Winter movement at all sites except Lower Brown appeared to be caused largely by raindrop splash. At the Lower Brown site splash was also active, but most of the soil was moved into the trough by surface flows concentrating on impervious rock areas and picking up material from areas of colluvial soil immediately above the trough.

The nature of the materials moving into the troughs was highly variable from site to site. Catches at the Upper Brown site ranged from 43 to 46 percent organic, mostly leaves and twigs; catches at the Lower Brown site were only 2 to 8 percent organic. At all sites except Lower Brown practically all of the material consisted of fines and organic matter. At the Lower Brown site some 12 percent of the material was rock with mean diameters greater than 4.5 inches, the largest rock weighing 156 pounds.

It is intended that the study sites, when sufficiently calibrated, will serve as areas where treatments may be applied and evaluated. Tests have been made of the degree of calibration achieved at the Lower Brown site using data recorded to date. The methods outlined by Wilm (Trans. Amer. Geophy. Union, vol. 30, pp. 272-8, 1949) were used. From analyses of data of weekly catches at the Lower Brown site it was estimated that if treatment were applied to the area above the 0-43-foot trough section, continued measurements of the catches at this section and at the 61-68-foot trough section (untreated) would permit (1) detection of a treatment effect of 13 percent in an average year during the fall and winter seasons, and (2) detection of a treatment effect of 32 percent in the summer season, both on 19 to 1 odds. Attempts will be made to improve the degree of calibration for the summer season by including a climatic control.

The amounts of soil caught in the individual segments of the troughs at two of the study sites have been related to the slope characteristics above the respective segments. The catches during the dry season at the Falls site were found to increase uniformly with increases in the length of the slope above the trough segment. On the other hand, at the Upper Brown site no clear relation between catch and slope length was found. This contrast suggests a different manner of movement at the two sites. At the rejuvenated Falls site the soil moves like a stream down the whole slope length, whereas at the nonrejuvenated Upper Brown site, the soil moves step-by-step down the slope, with only the bottom step spilling into the trough. It was hypothesized, then, that at the Upper Brown site the brush stems in some area relatively near the trough

might be controlling the amount of movement. Graphical tests were made of the relation of sediment catches in the individual 20-foot segments of the trough to (1) the sum of stem diameters (live and dead), (2) the number of stems, and (3) the basal area of stems within 6 feet above the trough lip. The first test gave the closest relation, as was anticipated, but even for this one the relation was not very good. Perhaps, use of a greater area above the trough or introduction of other variables will improve the relation.

Future plans include (1) calibration of the Falls site to test what magnitudes of treatment effects can be detected, and (2) correlation of dry season and wet season movements with climatic variables so that frequency of movement rates and mean annual movement can be estimated. In addition, it seems desirable to explore methods of evaluating, as erosion sources, the intermediate areas between the slope classes now set up, between nonrejuvenated and rejuvenated slopes, and between rejuvenated slopes and channel slopes.

Cover Improvement Studies

Growth Studies--Seeds of species recommended for erosion control work in southern California are still arriving from foreign cooperators. Fifty-nine seed collections have been received. Exotic and native species grown under controlled conditions during the past 6 months have been classified with respect to their growth at several temperatures (Quarterly Report, January-March 1953). The categories and recently-tested species are:

A. Species whose growth at all temperature conditions falls within 33-167 percent of average growth:

Pinus brutia	- Cyprus
Ceanothus crassifolius	- California

B. Species favored by low temperatures:

None

C. Species favored by moderate temperatures:

Spartium junceum	- Israel
Cercis siliquastrum	- Italy
Adenostoma fasciculatum	- California

D. Species favored by high temperatures:

Zizyphus lotus	- Israel

Frost Studies--Frost tests have been conducted in a refrigerated room at temperatures of 0° C., -5° C., and -10° C. To date, the work has consisted primarily of developing a satisfactory hardening process for the plants prior to subjecting them to the frost test. At least one month of growth under a 17° C. day and a 4° C. night is currently being used. During this time no nutrients are supplied to the plants and watering is stopped one week before frost testing. Age of plant appears to be one of the key factors in frost resistance; the present findings will apply only to the younger plants. The laboratory results will be checked in the field by observing plants of the same species grown in plots for taxonomic identification.

Drought Studies--Drought resistance studies have shown that a good test for one species is not necessarily applicable to a second species. Using native species that are known to live through the long southern California dry summer season, a laboratory test was conducted to establish criteria for a procedure to test the drought resistance of exotic species. The test consisted of a gradually reduced watering rate and finally the cessation of watering. The plants and containers were then weighed periodically until no further weight loss was recorded. After a 2-week period with no additional loss in weight, the plants were again watered. Scrub oak (Quercus dumosa) and Coulter pine (Pinus coulteri) were able to recover from this treatment. Two perennial bunch-grasses, Poa scabrella and Melica imperfecta, responded quite differently from each other. At the end of the drought period none of the grass plants of either species had any green blades. The Poa plants responded rapidly when placed under good growing conditions, while the Melica plants failed to recover. Both of these grasses grow on dry sites in Los Angeles River watershed.

Nitrogen Fixation Studies--One of the most exciting things of the past 6 months has been to watch the results of tests for nitrogen fixation by Ceanothus leucodermis and C. crassifolius. With each test it became more evident that these species, through their nodules, are capable of fixing atmospheric nitrogen for plant use. Ceanothus leucodermis grew better under the conditions of the test than did C. crassifolius but both showed significant increases of nitrogen content.

MEETINGS

November 5-7.--Gleason and Colman attended the Annual Meeting of the Soil Conservation Society of America, at Colorado Springs.

November 18.--Kraebel gave an illustrated talk to 50 members of the Sierra Club, in Berkeley, on watershed damages in California and what the Forest Service is doing to prevent them.

December 2-4.--Colman attended the Resources for the Future meeting in Washington, D. C. He participated in sessions of the Watershed Values subsection of section II--Utilization and Development of Land Resources,

December 9-10.--Colman took part in the Reno, Nevada meeting of Economics of Range Resource Development Committee (WAERC), discussing the hydrologic aspects of range management.

December 21-22.--Hellmers attended a meeting of the California Section, American Society of Range Management, at Davis. He gave a talk on "Use of Laboratory Techniques for Determining the Germination and Growth Characteristics of Grasses."

January 8.--Wyckoff, Colman, and Sinclair attended a meeting of the California State Board of Forestry held at Los Angeles. Later in the day they also attended a joint meeting of the State Board of Forestry and State Water Resources Board. Colman addressed the joint meeting on the subject of "Watershed Management in California." In this discussion he outlined the watershed management problems and the need for research in various areas of the State.

January 11-22.--The National Forest Engineers of Region 5 held a 2-week meeting in Glendora. The Regional Engineer, his staff, and other representatives from the Regional Office, as well as several Forest Supervisors, took part in the sessions. Colman, Kraebel, Sinclair, Horton, and Hellmers gave talks during the course of the meetings. The Engineers were taken on field trips over the San Dimas Experimental Forest and Los Angeles River Watershed. On the latter trip, Anderson explained the soil movement study being conducted in Los Angeles River Watershed, and showed the group one of the study areas.

January 13.--At the University of California Gleason discussed "Forest Influences as Applied Ecology" for Prof. Stone's class in Forest Ecology.

January 14.--Wyckoff, Colman, Sinclair, and Hellmers met with the Forest Service Region 5 Advisory Council at Pasadena. The meeting was followed by a field trip to residential areas in Monrovia and Sierra Madre endangered by flood runoff from watersheds recently denuded during the Monrovia Peak fire.

January 15.--Forest Service Region 5 Advisory Council visited the San Dimas Experimental Forest and held a meeting at Tanbark Flat. The California Station was represented by Wyckoff, Colman, and Sinclair.

January 22.--Hellmers spoke at a meeting of the California Institute of Technology Associates on the subject of "The Selection of Plants by Laboratory Screening Procedures for Introduction into a Particular Climate."

January 25.--At San Jose State College Gleason spoke on "Watershed Management and Indicators of Erosion" at Prof. Kartschner's class in Conservation.

January 27.--Horton discussed "Chaparral and the Fire Climax" at a Bio-ecology seminar at Pomona College.

January 29.--Anderson, Hamilton, Rowe, and Sinclair attended the Pacific Southwest Regional Meeting of the American Geophysical Union held at the University of Southern California.

February 3.--Horton discussed the recent fire-flood sequence in Wolfskill Canyon, and watershed management research on the San Dimas Experimental Forest at a meeting of students from California Polytechnic Institute interested in soil conservation.

February 17.--Sinclair spoke at a meeting of Pasadena Post 13, American Legion, on the subject of "Recent Fires and Floods in Southern California." The Conservation Committee of Post 13 celebrated its 30th anniversary at this meeting.

February 18.--At the annual meeting of the San Dimas Water Company, Sinclair discussed the recent fire and flood events in the San Dimas Experimental Forest.

March 2-3.--Colman attended the Sacramento, California, meeting of the PSWFIATC.

March 8.--Kraebel talked to the Men's Club, First Congregational Church, Berkeley, on "Water, Soil, and Forests." The lecture, illustrated with Kodachromes and enlarged photographs, was attended by 80 persons.

March 19.--Colman and J. R. Bentley (of Range Research) presented a discussion of brushland burning at a meeting of the Sierra Club in San Francisco.

COOPERATION

Regional Office.--The growth of annual ryegrass and mustard sown for erosion control in six 1953 burned areas on the 4 national forests of southern California was appraised in a field examination March 22-31. Participating for the entire trip were N. F. Meadowcraft, of the Regional Office and C. H. Gleason of the Station. Other Regional Office and Station men took part from day to day, together with local forest officers. An office report of the findings will be prepared.

Six Rivers National Forest.--In response to a request from Forest Supervisor Fischer, Kraebel prepared a memorandum on methods of sand dune stabilization to protect the water supply reservoir of a plywood mill in northwestern California. In four years, following the removal of a natural stand of shore pine (Pinus contorta) at the edge of a county airfield, the shifting sands had advanced 50 feet into the lake. The memorandum amplified, for this specific problem, the information contained in U.S.D.A. Circular 600 which appeared in 1942 and is still the best American reference on coastal dune stabilization.

Sierra National Forest--Colman took part in a Regional Office-Station-Forest examination of the Hazlett Basin, an area the Forest plans to subject to intensive management for demonstration and study purposes. The prime purpose of management here is to ensure the best water yield from lands ranging in cover from grass and brush in the foothills to timber in the snow-pack zone. Cover improvements, domestic and wild livestock management, and timber management will be included in the operation of this area.

Angeles and San Bernardino National Forests.--Hellmers and Horton examined watersheds denuded by the Monrovia Peak and Barrett fires, and made recommendations for seeding portions of the burns to mustard and ryegrass.

San Bernardino National Forest.--The Heaps Peak plantation, situated near Lake Arrowhead on the San Bernardino National Forest, was planted by the California Forest and Range Experiment Station during the years from 1930 to 1936. It has now developed into a beautiful grove of trees which the National Forest hopes to develop as a demonstration area. At present, the grove is dominated by a group of big-trees (Sequoia gigantea) measuring 40 to 50 feet in height. Several other species, such as Coulter pine (Pinus coulteri) and incense cedar (Libocedrus decurrens), have also developed into large trees. As the result of a query from the National Forest, Horton has summarized the data on survival and growth of the trees planted in this area. These data show, in addition to the excellent growth of the species already mentioned, that (1) Coulter pine, even at this altitude of 6,250 feet, grew more rapidly than either ponderosa or Jeffrey pine; (2) Pinus pinaster and P. tabulaeformis grew more rapidly than any other species of pine; (3) a higher percentage of trees survived from spring plantings than plantings in December.

San Bernardino Chamber of Commerce.--The San Bernardino Chamber of Commerce requested advice from the San Bernardino National Forest concerning restoration of the Arrowhead landmark, a prominant feature on a slope of the San Bernardino Mountains overlooking the valley to the south. This arrowhead-shaped area of light colored vegetation, principally lupine and sage, was formerly surrounded by dark green chamise chaparral. Recent fires, including one in 1953, have decreased the number of individuals in the chamise chaparral until there are now too few to develop the original dark green vegetation. The National Forest requested that Horton determine the possibility of restoration. After a survey of the Arrowhead, he reported to a committee of the Chamber of Commerce that restoration of the landmark could be accomplished only by planting shrubs in the surrounding depleted chamise chaparral. The vegetation of the Arrowhead itself will recover naturally, even though large gullies have formed on its surface in the last winter.

Bureau of Standards.--The annual report of research projects on the San Dimas Experimental Forest was prepared for the next issue of "Hydraulic Research in the United States."

University of California.--Selected lysimeter data were made available to Ami Y. Shachori, a graduate student, for use in a term paper on the "Influences of Different Types of Vegetation on Infiltration."

California State Department of Education.--George Shaftel visited Glendora to obtain illustrative material for a reader on conservation he is preparing for the seventh grade under State auspices.

Kolbe and Kolbe, Consulting Engineers, Los Angeles.--E. H. Graham, Jr. conferred with Rowe concerning information on infiltration for use in determining drainage requirements of areas being developed near Bakersfield.

Rocky Mountain Forest and Range Experiment Station.--Anderson reviewed and commented on L. D. Love's manuscript "The Effect of Killing Spruce and Pine by Bark Beetles on the Streamflow of the White River, Colorado." Included in the comments was a list of suggested hydrologic and statistical precautions to be considered in such analyses.

VISITORS

During the last six months the San Dimas Forest has had less than the usual number of visitors. In addition to those who attended meetings at Glendora or Tanbark Flat referred to earlier in this report, the list included:

October 10.--Forty teachers from Los Angeles City Schools interested in conservation.

November 10.--Nineteen men from countries of the Near East interested in forestry, range management, soil erosion, and general agricultural problems.

December 15.--Izchak Lanir, foreign student at Utah State Agricultural College, on leave from Israel.

January 27-28.--Jose Nicolas and Fernando Gil, foresters from Spain who are carrying on a study of land use in Spain and California. These men have, since, spent considerable time in the Berkeley office.

February 8-9.--Hsuan Keng, botanist from Formosa.

February 8-11.--Ami Shachori, forester from Israel, at present a graduate student at the University of California.

February 20.--Twenty members of the Beekeepers' Association of Southern California.

March 27-28.---Twelve members of the Conservation Committee, Pasadena Post 13, American Legion.

COMMENTS BY HENRY HELLMERS ON "TOPOCLIMATOLOGY" BY C. W. THORNTHWAITE

I can only agree with Dr. Thornthwaite when he says that the field of climatology, as known in the past, must change. This is particularly true if climatological information is to be of real value to those who work with the land. By the word "land" I mean small specific areas such as one slope or possibly even an entire watershed. Today climatology is too general, and applies to large areas, not to management units as we know them in forestry.

Studies on the heat and moisture budgets can become very complicated, as he carefully indicates. This has been demonstrated by work on a simpler system than a land mass ("Interim Report; Lake Mead Water Loss Investigations" by E. R. Anderson, L. J. Anderson, and J. J. Marciano, published by the U. S. Navy Electronics Laboratory, San Diego, California, 1950). Unfortunately, I could find no references to what Thornthwaite refers to as the "famous Nebraska micrometeorological expedition" so am not familiar with the problems they encountered or the results that were obtained. One factor that Dr. Thornthwaite failed to mention was dew. In some locations the dew can possibly be a very critical factor, but it is only one of the many to be considered.

The term "topoclimatology" appears to be very applicable to the problem, and is not to be confused with microclimatology as commonly used in the field of ecology.

With the understanding of topoclimatology, a long step will have been taken towards solving many of the problems of watershed, timber, and wildlife management, as well as the problems of ecology and fire control. Even though the study of topoclimatology is a long term one and is still in the instrumentation stage, it is my opinion that it could be considered and undertaken as an important problem by the Forest Research Branch.

SEMIANNUAL REPORT
October 1953 - March 1954

Forest Influences Division
CENTRAL STATES FOREST EXPERIMENT STATION

Buckeye Research Center

General

Increasing interest in soil and water conservation is being shown in Ohio by the general public. This interest has been encouraged by accomplishments of the Muskingum and Miami Conservancy Districts and by the Soil Conservation Service. Interest has been further aroused by recent meetings including the Third Annual Ohio Water Clinic held in February on the campus of Ohio State University. Activities of the Soil Conservation Service on Rocky Fork and on Hunter's Run, the two Ohio pilot watersheds, are being followed with considerable interest.

Added interest in soil and water conservation has resulted from the effects of the present drought that is general throughout Ohio and the Central States region. The precipitation deficiency at Columbus, Ohio for the past 20 months is approximately 18 inches. Many communities with inadequate water supplies have been forced to limit the local consumption of water. Several communities with exhausted water supplies have been forced to haul water for domestic needs. The drought has aggravated the soil and water problems that confront this region of intensive agricultural and industrial activity. Irregular stream flows that fluctuate between severe floods and extreme low flows, rapid water runoff, soil erosion, sedimentation, and lowered water tables are all conditions that reflect an improper use of watershed lands.

The soil and water problems of the Central States region will receive much attention in the future as public interest is converted into programs of action designed to solve the water problems that threaten to limit the industrial expansion of the region. The situation can be viewed as a challenge to forest-influences research. Major soil and water problems must be recognized and studied in their order of importance in order to provide answers to the most critical regional problems. Methods of forest management must be developed that will protect and improve the soil and water values of forest land in the Central States region.

Meetings

In November, Carmean attended the annual meeting of the Soil Science Society of America at Dallas, Texas. He presented a paper on the soil and site relationships of Douglas-fir in southwestern Washington. Enroute to this meeting Carmean visited the Southern Experiment Station centers at Oxford, Crossett, Vicksburg, and Nacogdoches.

In February, Carmean and Director McGinnies attended the Third Annual Ohio Water Clinic held in Columbus at Ohio State University.

The first meeting of the Advisory Committee for the Buckeye Research Center was held in March at Athens, Ohio. This committee consists of 14 officials representing industrial, agricultural, state, and federal organizations concerned with activities in forestry, lumbering, soil, and water. Merz presented a problem analysis on the forest research program of the Buckeye Center. Plass discussed the research program on the Vinton Furnace Experimental Forest, and Carmean discussed the forest influences program at the Buckeye Center.

In April, Carmean will present a paper on "Structure of forest soils," to the Conservation Section of the Ohio Academy of Science.

Publications and Manuscripts

"Site-index estimates made easy," by R. W. Merz, was published in October in the Journal of Forestry, Vol. 51 (10): 749-750.

"Mineral content of leaves clue to white oak site quality," by R. F. Finn, was issued in November as Central States Forest Experiment Station Technical Paper No. 135.

"Growth of planted red and white pine in Ohio and Indiana," by R. N. Gaiser and R. W. Merz, was issued in December as Central States Forest Experiment Station Technical Paper No. 138.

"Site quality for Douglas-fir in southwestern Washington and its relationship to precipitation, elevation, and physical soil properties," by W. H. Carmean, will appear in the July issue of the Soil Science Society of America Proceedings. An enlarged version of this paper that includes site tables and curves is now being reviewed and will be submitted to the Journal of Forestry.

"Structure of forest soils," by W. H. Carmean, is being written for publication in the Ohio Journal of Science.

Two unpublished manuscripts prepared by the late R. N. Gaiser are being reviewed for eventual publication. These manuscripts are "Accumulation of litter beneath oak stands of southeast Ohio," and "Effect of forest cover on infiltration rates of water into soil."

Precipitation

Nine rainfall recording stations were installed in August on the Vinton Furnace Experimental Forest. Data now available from these stations show the continued rainfall deficiency now affecting the Central States region. The 7.55-inch rainfall deficiency since September added to the approximately 10-inch deficit of the previous 14 months equals a total precipitation deficit of almost 18 inches during the past 20 months.

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Vinton Furnace Expt. Forest (1953-1954)	1.24	0.48	0.99	2.21	2.79	1.45	9.16
Expected[1/]	2.78	2.28	2.68	3.06	3.32	2.59	16.71
Deficiency	+1.54	+1.80	+1.69	+0.85	+0.53	+1.14	+7.55

1/ Based on 24-year average at McArthur, 12 miles from Vinton Furnace.

Research Program

Conversion of poor-site hardwood ridges to pine.--This study is essentially a forest management study made to determine the feasibility of converting poor-site hardwood ridges to pine. The conversion will be accomplished by clearcutting the hardwoods and planting pitch, shortleaf, and white pines. Competition from hardwoods will be controlled by poisons.

As a supplement to the above, a study will be made of the effects of clearcutting and pine conversion on soil, soil moisture, and humus development. Information is especially needed on the effects of this silvicultural treatment on the basic productive capacity of ridges and on the associated values of soil and water.

The hardwoods have been clearcut and the pine will be planted in April. Immediately following the planting of pine, periodic measurements and observations will be made of soil and organic layer developments. Water runoff troughs will be installed to determine the quantity of water runoff and sedimentation from the study plots. Weekly soil moisture samples will be taken by means of "King Tubes."

Future Plans

A problem analysis for the research program in forest influences at the Buckeye Research Center is now being written. This problem analysis will appraise the nature, extent, and relative importance of the forest influence problems of the Buckeye area and will suggest a program of research for the study of these problems.

It is hoped that several small watersheds on the Vinton Furnace Experimental Forest will soon be equipped with weirs and water level recorders. These watersheds will undergo a period of calibration preparatory to future experimental study on the effect of forest management practices on the quantity and quality of water yield.

Soil-site studies on the relationships between tree site quality and soil and topographic features of southeastern Ohio will be continued this year. These studies, completed for white oak, and red and white pines by the late R. N. Gaiser, will include black, chestnut, and red oaks, hickory, and possibly pitch and shortleaf pines.

SEMIANNUAL REPORT OF FOREST INFLUENCES INVESTIGATIONS
Intermountain Forest and Range Experiment Station
October 1953 - March 1954

Great Basin Research Center

The bulk of the effort at this center was devoted to checking, revising, and improving the draft of a report on the behavior of the Area A and B watersheds. One phase of this effort included a study of the factors which influence the volume of soil eroded per unit volume of summer storm runoff.

This study showed antecedent rainfall to be the only climatic factor having a significant bearing on the soil erosion-runoff ratio. As the depth of antecedent rainfall increases, there is a highly significant decrease in the volume of soil erosion per unit of runoff. Previous analyses had established that the greater the antecedent rainfall the greater the amount of runoff to be expected from a given storm. The decrease in the amount of eroded material per unit of runoff with increased antecedent rainfall is believed to be due to the fact that sluicing of loose material from the rills and gullies by antecedent rains leaves less material for a subsequent storm to carry away.

Antecedent rainfall was found to be more closely related to the soil erosion-runoff ratio of watershed B than that of watershed A. After isolating effects of antecedent rainfall, the residual ratios for watershed B occurred randomly in time, indicating no over-all change associated with depletion of watershed cover. On Area A, however, there has been not only a decrease in summer storm runoff in relation to rainfall factors but also a decrease in the volume of soil eroded per unit of runoff as watershed conditions improved.

A new rating curve and discharge table were developed for the flume on the Left Fork watershed and 13 years of streamflow records were calculated. This sets the stage for comparing the behavior of this watershed with that of the Alpine Cattle Pasture watershed. These two high elevation areas have been undergoing calibration with a view toward using them to evaluate the effects of intensive summer range-watershed improvement measures.

Wasatch Research Center

The principal effort at this center has been on the analysis of streamflow records from several of the experimental watersheds.

One year of streamflow records obtained from temporary gauges on two forks of Chicken Springs watershed were disappointing. These records showed measurable runoff to be less than 50 percent of what was expected, clearly indicating that much of the runoff was seeping out either lower down in Farmington Canyon or in some other watershed. It was hoped that these small watersheds would be suitable for evaluating the effect

of aspen cutting on water yields. The records will be studied further but it appears that the areas are not suitable for the original purposes.

A comparison of runoff from Miller and Morris Creeks revealed some variations which are believed to be due to differences in the amount of snow that is blown into and out of these catchment areas. It is believed that a wind correction factor can be introduced into the prediction equations which will substantially reduce the variations. This factor is now being studied.

Two graduate students at the University of Utah are completing a study of vegetational changes in Morris and Miller watersheds as part of a cooperative effort jointly financed by the Station and the University.

Further analyses were made of the comparative behavior of runoff from the Centerville and the Parrish watersheds. The stream channel in the latter was badly ripped during the mud-rock floods of 1930 whereas the Centerville channel has never been materially disturbed.

Time trend analyses show that annual runoff from Parrish Creek has consistently declined since 1936, as compared to Centerville Creek. The over-all change in the yield from Parrish Creek has been about 2.0 inches, or about 15 percent of the average annual yield. Summer season streamflow from Parrish watershed has also declined in recent years, though less markedly than annual runoff.

There has been no change in October yields of water from Parrish Creek. Inasmuch as transpiration losses are negligible in October (following September frosts), the absence of any change in runoff during October as compared to substantial changes in summer and annual yields, clearly suggests the recent decreases in runoff to be due to reinvasion of the ripped channels by riparian vegetation.

Boise Research Center

Efforts here have been devoted mainly to revisions of several manuscripts and development of plans for further soil stabilization studies on ponderosa pine logging areas and foothill rangelands.

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Forest Influences
Semi-annual Progress Report, October 1, 1953 - March 31, 1954

General

Interest in the subject of watershed management continues to grow in the Pacific Northwest. In the past six months this fact has been particularly evident in the State of Oregon.

A major focal point has been the Governor's Water Resources Committee operating under the chairmanship of Chief-emeritus Lyle Watts. His group has just completed a series of fourteen hearings held throughout the State for the purpose of learning about local water problems. Need for watershed management was a prominent subject of discussion at each meeting, and support for better upstream control was voiced repeatedly. Watershed management research received a measure of support also, particularly in testimony by the Forest Service.

The cause of watershed management research received additional boost in the form of resolutions adopted by two prominent organizations. At their annual state convention in Eugene last December the Izaak Walton clubs of Oregon urged additional watershed investigations on forest and range lands. A resolution with similar intent was introduced by a prominent Oregonian at the February convention of the National Association of Soil Conservation Districts and subsequently passed by that group. The Station had a part in both of these developments.

South Umpqua River

Extreme fluctuation in the flow of the South Umpqua River in southwest Oregon has heightened local interest in the relation of streamflow to logging. Lack of real information has left room for much speculation. The Roseburg, Oregon, Chamber of Commerce has urged a study leading to plans for river control. In February Lloyd Hayes, our research center leader in Roseburg, was asked to make an analysis of streamflow records to point up the problems more specifically. His analysis of USGS data showed basic differences in hydrologic characteristics in the North and South Umpqua drainages. Chief reasons are traced to soil,

vegetation it supports, and the influence of elevation on type of precipitation received. As a result, the ratio of average flow for highest and lowest months of record is 1 : 16 for the North Umpqua in contrast to 1 : 170 for the South Umpqua.

The basic problem, Hayes concludes, lies in the fact that the South Umpqua watershed is basically inefficient. Although he was not able to relate streamflow behavior to the progressive effects of logging, he recommends a great deal more care in logging and restoration of a full-density cover of timber.

In this connection Hayes makes an interesting suggestion. Clay subsoil in the upper reaches of the watershed is penetrated poorly by Douglas-fir, but pine roots penetrate it deeply. Therefore, he recommends replacing Douglas-fir with ponderosa and sugar pine. In a transition zone such as that occupied by the South Umpqua basin, the suggestion may have merit.

He concludes that manipulation of forest cover will be slow at best and probably be inadequate to fully control the excessive stream fluctuations. Engineering works such as water detention and storage reservoirs provide the only rapid solution. He points out that erosion control will be a necessary corollary.

Mid-Columbia Progress

In the State of Washington the greatest interest in watershed management has developed in the Mid-Columbia area. In part this has been heightened by the selection of Mission Creek near Wenatchee as a pilot drainage in the Department's new small watershed demonstration program.

Aside from this, however, there is a strongly developed regard for water in the whole area. Their economy is so closely tied into irrigation and water power that public awareness of dependency on water is exceptionally acute.

Possibilities for getting watershed management research started on a cooperative basis in the Mid-Columbia area are being explored. The subject will be the theme at the spring meeting of the Yakima Valley Advisory Council, a group specifically interested in activities on the Wenatchee and Snoqualmie National Forests.

Meetings

Watershed management research has been discussed at various meetings held during the late fall and winter. Dunford described watershed problems and research needs at the following gatherings:

1. Region 6 Junior Forester Orientation Course, Portland, Oregon.

2. Station Advisory Committee, recently formed and meeting for the first time in February, Portland, Oregon.

3. Deschutes Research Center Advisory Committee, Bend, Oregon.

4. Oregon Water Resources Committee hearing, Eugene, Oregon.

Dunford also attended part of the Regional Training School for staff engineers in March. Subjects included road construction, drainage standards, contract specifications, and maintenance problems.

Publications

Two manuscripts on the bunchgrass and ponderosa pine surface runoff plots at Manitou Experimental Forest (Colorado) were prepared by Dunford. One of these has been accepted for publication by the Journal of Forestry. The second deals with the same subject with greater emphasis on the relation of storm characteristics to runoff and erosion. It will appear on the program of the American Geophysical Union at their May meeting in Washington, D. C.

A review of research in soil frost has been prepared by W. E. Bullard (Region 6, Flood Prevention Project Unit). This excellent summary will appear on the program of the International Union of Geodesy and Geophysics at their meeting in Rome, August 1954. Title of the paper is, "A review of soil freezing as affected by snow cover, plant cover, and soil conditions in northwestern United States." Limited copies are available.

What is Watershed Management?

A move is again under way to change our name to Division of Watershed Management Research. Looks as if it might go through this time. If it does, or even if it doesn't, maybe we should agree on what watershed management really means. One definition has been supplied by Croft in one of his recent articles.[1/] He places water management on a level with that of timber and grazing, based on the well-recognized multiple-use theory that all three are watershed resources. Watershed management, then, becomes the integration of these three activities, as well as others which may exist on a watershed.

This definition is, in many ways, a logical interpretation of our field of work. However, when used to describe the research objectives of our division, its scope is all-inclusive and open to criticism by loyal members of the range and forest management research divisions. Perhaps some discussion of the term might help clear the air.

1/ Croft, A. R. 1953, "Water management on rangeland: a responsibility of range managers." Jour. Soil and Water Conservation, 8 (4): 158-162. July 1953.

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Dunford also attended part of the Regional Training School for staff engineers in March. Subjects included road construction, drainage standards, contract specifications, and maintenance problems.

Publications

Two manuscripts on the bunchgrass and ponderosa pine surface runoff plots at Manitou Experimental Forest (Colorado) were prepared by Dunford. One of these has been accepted for publication by the Journal of Forestry. The second deals with the same subject with greater emphasis on the relation of storm characteristics to runoff and erosion. It will appear on the program of the American Geophysical Union at their May meeting in Washington, D. C.

A review of research in soil frost has been prepared by W. E. Bullard (Region 6, Flood Prevention Project Unit). This excellent summary will appear on the program of the International Union of Geodesy and Geophysics at their meeting in Rome, August 1954. Title of the paper is, "A review of soil freezing as affected by snow cover, plant cover, and soil conditions in northwestern United States." Limited copies are available.

What is Watershed Management?

A move is again under way to change our name to Division of Watershed Management Research. Looks as if it might go through this time. If it does, or even if it doesn't, maybe we should agree on what watershed management really means. One definition has been supplied by Croft in one of his recent articles.[1/] He places water management on a level with that of timber and grazing, based on the well-recognized multiple-use theory that all three are watershed resources. Watershed management, then, becomes the integration of these three activities, as well as others which may exist on a watershed.

This definition is, in many ways, a logical interpretation of our field of work. However, when used to describe the research objectives of our division, its scope is all-inclusive and open to criticism by loyal members of the range and forest management research divisions. Perhaps some discussion of the term might help clear the air.

1/ Croft, A. R. 1953, "Water management on rangeland: a responsibility of range managers." Jour. Soil and Water Conservation, 8 (4): 158-162. July 1953.

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
FOREST INFLUENCES
Semiannual Report -- October 1, 1953 - April 1, 1954

Continental Divide Research Center

Principal attention during the past 6 months has been placed on working up the backlog of records for the Fraser Experimental Forest. Efforts are being made to improve computation methods and we hope to plan new work so that field collection of data and compilation will be simplified.

A different chart reading technique

Previously, in reading stream-gage charts we have used the "all break" method which is essential when there is interest in the characteristics of storm runoff. Using this method, it has required a minimum of 10 to 15 man-days to read the charts and compute the daily discharges associated with 6 months of spring and summer record.

In studies in the high mountains where most of the streamflow originates from snow, storm runoff is of minor concern. Our past and present watershed studies are directed primarily to determining the effect of forest density reduction on the seasonal and annual discharge. With this objective there is no interest in the discharge during time intervals of less than 1 day and the chief interest is in seasonal totals. A procedure of chart reading has been adopted which gives daily totals with satisfactory accuracy and requires around one-fifth or less of the time involved in the all-break method.

The essence of the method was suggested by the U. S. Geological Survey, Denver, where it has been applied for a lengthy time. A transparent straight edge is used and, for the time period chosen, the area above the edge but below the trace is balanced by eye against the area below the edge and above the trace. Only one reading of stage is made, that corresponding to the midtime of the period. During late summer and fall, when little fluctuation in stage occurs, a 24-hour period is used. A 12-hour period is used for most other days. For a few days each year when exceptionally large fluctuation occurs because of snowmelt or a rare, heavy storm, periods as short as 1 hour are taken to enable the accurate balancing of areas.

This method was subjected to thorough testing before adoption. Daily totals obtained by the all-break method were compared with similar data based on the new method. Thirty-eight days were used, chosen from periods when maximum fluctuation occurred. For only 2 days was the discrepance more than 1 percent and in no case more than 1.2 percent. The differences were randomly plus and minus, so for longer periods the differences were less. Between weekly totals, the differences did not exceed 0.2 percent and 5-week totals differed by only 0.02 percent.

As part of the development of this method, a study was made to determine the allowable range in head over a chosen time period in order that the error consequent on reading the mean head would be negligible. Such an error exists because of the curvature of the usual head-discharge relationship. A similar error is encountered if two head values are read and the corresponding discharges are averaged, although in this case the error is slightly less.

An equation was worked out from which the allowable range in stage can be computed by introduction of the exponent appearing in the head-discharge relationship. The specific equation used was predicated on the acceptance of a 1 percent discrepance between the true value for discharge and the discharge obtained through the compilation procedure. Solutions were made which are applicable to 1-foot San Dimas flumes (a rating equation exponent of 1.310) and to rectangular sharp-crested weirs (King's exponent 1.47). For San Dimas flumes the allowable range in head turned out to be 60 percent, that is, the higher value of head can be 60 percent greater than the lesser value. The comparable figure for the sharp-crested weir is 40 percent. The determining factor is the magnitude of the rating equation exponent, which of course determines the curvature of the relationship between head and discharge. The greater the magnitude of the exponent, the less the allowable range in head.

More useful snow survey data -- maybe

Another development of interest to us at least, appeared during study and analyses of snow survey data collected from two experimental watersheds over the past 8 years. Snow courses were originally established on these watersheds with the expectation that they would be useful to the prediction of streamflow. At least one of the watersheds is to be treated and some method is necessary whereby, after treatment, the streamflow without treatment can be reliably estimated. It was expected that the snow-course data would be useful in such estimating.

Previous analyses using data from all snow-course stations indicated the expectations to be ill founded. Based on 8 years of record, the correlation between snow-course water-equivalent averages and stream discharges was statistically nonsignificant.

Recently, some of these data have been reexamined to see whether results equally as good, at least, could not be obtained if only a portion of the whole long snow course was surveyed. Results indicated this to be true but they also suggested more. Based on a system of rating an individual station according to the conformance of its record with subsequent streamflow, the better stations were selected from among the total. Using the average water equivalent at these better stations only, a correlation with streamflow well above significance was obtained. For the one watershed on which analyses are temporarily complete, the correlation coefficient using all 64 snow-course stations has a value of 0.587. A corresponding figure of 0.884 was obtained when only the "best" eight stations were used.

At present, these results are considered to be suggestive only. They suggest that perhaps a few, key, snow-sampling stations on a watershed are better than a large number which have been located in a more or less mechanical manner. The suggestion will be acted upon in two ways. A list of the better stations will be carried along during the next survey and the locations of these particular stations studied critically to see if any conclusions can be drawn as to what is a good sampling site. Secondly, the analyses described here will be kept current to see if these stations persist in their good behavior or whether they only happened to be good by chance during the particular 8-year period.

Upper Colorado River Research Center

Badger Wash Cooperative Study

The objective of this study is to determine the effect of livestock exclusion upon runoff and erosion in the salt desert shrub type. It is a cooperative undertaking of the Bureau of Land Management, Geological Survey, Bureau of Reclamation, and the Forest Service. The semiannual report for last fall gives a more complete account of the plans for the study.

The accomplishments to date of the participating agencies are: completion of a soils map; a survey of vegetation; infiltrometer measurements on 24 pairs of plots; fencing of 4 watersheds; construction of dams on all 8 watersheds; a topographic survey; and the installation of rain gages.

The soil survey of Badger Wash showed that the soil on about two-thirds of the area of the experimental watersheds is derived from a mixture of shale and sandstone. The surface soil in this mixed type is a brown sandy clay loam about 7 inches deep on the average. Soils on the remaining third of the area are derived from either shale or sandstone. The shale type has a grayish brown silty clay surface soil about 7 inches deep, while the sandstone surface soil is a reddish brown sandy loam about 16 inches deep.

Measurements of vegetation, infiltration, and erosion were made in order to determine initial differences between watersheds. Some of these measurements which may be of general interest are reported below.

Ground Cover Based on the 3-Step Method

Soil type	Ground cover index				
	Plant cover	Litter cover	Moss	Bare soil	Rock
Shale	3.6	14.3	0.5	79.2	2.4
Mixed	4.0	14.5	2.2	53.8	25.5
Sandstone	6.5	27.8	6.1	53.1	6.5

Probably the most significant characteristic of the ground cover on all three types is the low plant density index. On the shale soils plant cover is chiefly shrubs, the main species being Atriplex gardneri. Plant cover on mixed soils is equally divided between grasses (mostly Hilaria jamesi) and shrubs, the most common of which are Atriplex

gardneri, Atriplex confertifolia, and Chrysothamnus spp. On sandstone soils the grasses (chiefly Hilaria jamesi) comprise most of the plant cover, with shrubs occurring less frequently than on other types. The main shrub species on sandstone soils is Atriplex confertifolia.

Average Infiltration Rates for Last 20 Minutes of Test

Soil type	Average infiltration rate	
	Dry runs	Wet runs
	Inches per hour	Inches per hour
Shale	0.68	0.63
Mixed	.80	.67
Sandstone	2.68	1.60

It can be seen from the table that infiltration rates for shale and mixed soils are quite similar (about 0.70 in./hr.); whereas the rates for sandstone soils are much higher. Average rainfall intensity during infiltrometer runs was about 5 inches per hour.

Erosion Rate From Infiltrometer Tests

Soil type	Erosion rate	
	Dry runs	Wet runs
	Tons per acre per inch of surface runoff	
Shale	3.13	2.69
Mixed	2.60	2.12
Sandstone	.28	.43

The remaining 24 initial infiltrometer runs will be made in the fall of 1954. In 1958 and at subsequent 5-year intervals further measurements of vegetation, infiltration, and erosion are planned in order to determine relative changes which occur on grazed and ungrazed watersheds.

Oak-Brush

Oak-brush cover is generally believed to be undesirable and cattlemen are interested in replacing it with grass wherever possible. There is little information available to judge the value of the oak-brush type for either watershed protection or forage production. A survey was made last summer in Delta and Montrose Counties to compare the vegetation and soils on areas covered by brush with that in openings within the brush. Some of the results of that survey are tabulated below. The tabulation is based on examination of 82 brush-covered and 82 open plots.

Comparison of Brush-Covered with Open Areas

Item	Open	Brush covered	Significance of difference 1/
Herbage production (lbs.per acre)			
Total for grasses and sedges	369	325	NS
All sedges	26	204	**
Bluegrass	140	53	*
Wheatgrass	62	11	**
Needlegrass	54	18	*
Other grasses	87	39	NS
Ground cover (percent)			
Ground cover density	68	95	**
Litter	48	72	**
Weeds	17	10	**
Bare soil	28	4	**
Soil			
Depth of litter and humus (inches)	0.3	2.5	**
Depth of surface soil (inches)	20.0	17.0	NS
Current erosion	Moderate	None	**
Soil stability	Fair	Excellent	**

1/ NS - difference not significant; * - difference significant at 5-percent level; and ** - significant at 1-percent level.

Front Range Research Center

As a result of the consolidation of the old Rocky Mountain and Southwestern stations, it is possible to increase influences research at this center. The main effort during the winter has been to bring up to date and compile past records. Old studies are being scrutinized to see if they are worth continuing and plans are being made for new work.

Considerable time has been spent reviewing the analysis of the infiltration studies made on the experimental pastures at Manitou. A study dealing with factors controlling the infiltration process is planned for the coming summer in hopes it will explain some of the results of past infiltrometer tests.

Plans are being made with the Range Management Division to test the effect of good grazing management practices upon streamflow and erosion. These studies will be made on watersheds up to 800 acres in size and will test alternate and seasonal grazing use. Observations indicate that such grazing practices combined with moderate stocking can be used in the Front Range without damaging watersheds.

Sierra Ancha Research Center

Mining claims on Sierra Ancha Experimental Forest

Two hundred or more mining claims have been filed on the Sierra Ancha Experimental Forest and more are filed every day. The claims are for radioactive material apparently present in the Dripping Springs Quartzite formation. The Base Rock Lysimeters and the Natural Drainage Watersheds are completely covered by claims and there are claims on the Parker and Pocket Creek Watersheds.

We are contesting these claims on the basis of prior use, the importance of the research, and the fact that the area was withdrawn in 1938 for research purposes. The outcome of the case is dependent on the courts and the mining companies are prepared to go to great lengths to win the case.

Experimental areas not yet withdrawn from mineral entry should be withdrawn under Executive Order 10355. However, even then if the General Land Office decides the area to be more valuable for mining than research, it can open the lands to mineral entry.

The history of the Sierra Ancha situation illustrates the problem. In 1938 the Sierra Ancha area was set aside for research purposes under the old L-20 regulation. In 1951 requests were made to the Department of the Interior to have the area withdrawn from mining entry. The requests were acknowledged but no action was taken because of the large number of requests awaiting action in the General Land Office. Again in 1953 a request was made to have the lands withdrawn under Executive Order 10355 (May 20, 1952--- 17 F.F. 4831) 3CFR, 1952, Supp. P. 77. After this request the description of the area was recorded in the plot books of the General Land Office. The lands are still not officially withdrawn but mining claims filed after the date of recording are subject to the withdrawal request.

Upper Rio Grande Research Center

The major land resource problems in northern New Mexico are either centered in or dependent on the deteriorated condition of the pinyon-juniper-sagebrush zone. The most critical range problem in this region is that of inadequate forage during the spring. Pinyon-juniper-sagebrush lands produce less than one-third of the spring forage requirements.

In order to alleviate this problem, Forest Service Administration has, on the basis of research findings, successfully reseeded about 35,000 acres during the past 5 or 6 years. Reseeding operations were guided entirely on the basis of increasing forage production. That this objective was accomplished is shown by forage clipping and grazing experiments which indicate forage yields were increased from 5 to 10 times by reseeding with crested wheatgrass. In one experiment, beef production on reseeded pastures averaged more than twice that on adjacent native ranges of equal grazing capacity.

It has been assumed that reseeding deteriorated rangelands would increase the infiltration capacity of the soil and reduce surface runoff and erosion, yet watershed values have thus far not been considered in the range rehabilitation program. An example of this is indicated by the direct application of range reseeding findings. Experimental trials show that wide spacing of crested wheatgrass plants is desirable from the standpoint of forage yield. Yet the large amount of soil exposed under wide spacing is not desirable from the standpoint of infiltration and soil stabilization.

The Rocky Mountain infiltrometer was used in the 1952 and 1953 field seasons to obtain a measure of the effect of reseeding on watershed values. An attempt was made to locate 4 conditions at each location, grazed and protected on both native and reseeded ranges. It was felt that although all lands reseeded to crested wheatgrass would be grazed, some measure of the effect of reseeding itself on infiltration and erosion was desirable. Likewise, the effect of grazing elimination on deteriorated native ranges is also needed.

Although the experimental design was adequate, an insufficient number of desirable sites were found. Moreover, at only 2 locations were all 4 conditions represented. Even at these locations soil and site differences occurred between conditions tested, necessitating detailed evaluation of each area separately. Another complication in this study was that once the reseeded ranges were grazed livestock failed to utilize herbage on the adjacent native ranges. So where reseeded ranges were grazed 1, 2, 3, and 4 years, the adjacent ranges were actually protected during these periods.

Infiltration-erosion tests were conducted at 7 locations during the 2 years of study with 1 location being sampled in both years. Although all analyses are not completed and an inadequate number of replications are available, the data seem to point to the following:

1. Ground preparation and seeding tends to increase the infiltration rate but this is reduced in time, particularly after livestock grazing with its associated trampling commences.

2. Ground disturbance in preparing a seedbed results in increased erosion rates but these decrease where trampling by cattle compacts the surface soil.

3. Reseeding with subsequent grazing as now conducted does not result in a significant increase in infiltration rates.

4. Whether concentration of cattle even for short periods of 30 days per year on reseeded areas will ultimately result in decreased infiltration is not yet known, though there is some indication that it may. The maximum number of years reseeded ranges were grazed is 4.

5. Although reseeding pinyon-juniper-sagebrush ranges as now conducted may fail to increase infiltration rates and decrease erosion rates on the site, it nonetheless provides a partial solution to the

overall land problem. Lands thus far reseeded are the better alluvial and colluvial bottoms, mesas and fans. Slopes are gentle, generally less than 10 percent. Concentrating livestock on reseeded lands removes animals from the adjacent, much steeper, shallow residual soils supporting scant herbage and where watershed problems are much more critical.

6. The Rocky Mountain infiltrometer measures infiltration and erosion rates but is too small in size to give a reliable measurement of initial retention through depression storage. There is some indication from inflow into stock tanks that roughing the land surface by ground preparation of seedbed results in an increased amount of depression storage.

7. Where watershed problems are paramount ground preparation for reseeding should include other measures such as pitting with eccentric discs, ridging, listing, etc., to increase initial retention through depression storage.

SOUTHEASTERN FOREST EXPERIMENT STATION
DIVISION OF FOREST INFLUENCES

PROGRESS REPORT
October - December 1954

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PROGRESS REPORT
October - December 1953

COWEETA HYDROLOGIC LABORATORY

Use of Silvicides and Water Quality

Municipal and industrial watersheds in the Southeast offer a fertile field for integrated water and timber management. Since most of them are in an unmanaged condition at present, the first step in obtaining integrated production from these areas involves timber stand improvement. The cheapest, most effective timber stand improvement these days is done by the use of silvicides. The use of silvicides in areas where the water supply is utilized for human or industrial purposes poses an added restriction on the silvicides that can be used. Not only must they be cheap and effective, but they must also not taste the water or impart objectionable impurities into it. Although tests have not advanced to the application stage, exploratory work in the past year has helped us to narrow the field of possible silvicides for use in municipal and industrial watershed timber stand improvement.

Sodium arsenite should not be recommended for use in municipal or industrial watersheds because of the adverse public relations that might result. Actually, the danger from sodium arsenite would be small; the danger would be greater to the fish in the stream than to humans consuming the very small concentration that might get into the water supply. Dave Cook sums up the use of sodium arsenite adjacent to streams in the June-July 1953 New York Conservationist; "In streams a high enough concentration will kill fish; lower concentrations may drive fish out by destroying the insects upon which they feed. But the introduction of that much chemical could come about only through carelessness (as from accidental spilling directly into the stream) or by someone washing a pail or brush in a brook. These possibilities seem to be exceedingly unlikely and can easily be avoided by proper training".

The silvicides 2, 4-D and 2, 4, 5-T impose several limitations also. Although neither 2, 4-D nor 2, 4, 5-T in ordinary concentrations will kill fish in the streams, 2, 4-D will impart a disagreeable flavor to fish flesh, making it impossible to eat. The carrier may cause off-flavor in the taste of water.

The first limitation should not be serious in treating vegetation along a flowing stream because the concentrations that could possibly get into the stream are very small. For example, the total amount of 2, 4-D used each day in painting stumps in a riparian cutting at Coweeta was such if all that was applied had fallen into the watercourse during the 8-hour working day, the concentration of 2, 4-D would have been approximately .1 p.p.m. Taste from carriers was not detected in tests while treating the riparian vegetation with 2, 4-D along 390 feet of stream channel.

One chemical house suggests the use of one of the refined oils as a carrier that is low in those fractions likely to cause off-flavor. The more refined oils do not reduce the effectiveness of the application as long as the oils used are of the boiling range of kerosene or higher.

Ammate in itself should not cause any difficulties for use in watershed TSI work. However, Ammate is currently formulated containing up to 1.5% sodium dichromate as a corrosion inhibitor and this hexavalent chromium is definitely objectionable in water supplies. Ammate can be obtained without the corrosion inhibitor added if a special request is made. Users of Ammate without the corrosion inhibitor should be cautioned to expect the worst as far as metal equipment corrosion is concerned.

The ideal silvicide for watershed purposes would be one that is non-toxic and taste free. E. I. Du Pont de Nemours and Company have developed a series of related silvicidal chemicals, the ureic compounds, that will meet these requirements. One of them is now commercially available, chlorophenyl dimethyl urea (CMU). However, the selectivity of the chemicals in this series and the methods of application must still be worked out.

Stream Temperature Study

A riparian vegetation cutting was made in early May, 1953 on an inter-watershed area. It was designed as the first in a series of studies in the management of riparian vegetation for fish production. The primary objectives of this phase of the study are:

1. the effect of length of riparian cutting required to cause changes in stream temperature.
2. the extent of stream temperature recovery in down stream forested areas.

The analysis of six months data on temperature measurements has led to the following conclusions with regard to stream temperature:

1. Diurnal fluctuations in water temperature disappear or are greatly reduced during rainy periods. The reduction in diurnal fluctuation extends for a period of approximately 48 hours following the end of the precipitation period on Shope Creek.

2. Diurnal fluctuation of water temperature was greater down the valley than upstream in this particular study. This was also true of air temperature.

3. There was no evidence in this study to support the hypothesis that the stream was abnormally warmed as a result of a 390 foot riparian cutting.

4. Water temperatures can be closely correlated with air temperature.

5. Caution should be exercised in differentiating the effects of a complete watershed cutting upon stream temperature as compared with a riparian cutting.

Estimating Treatment Effects with Time Trends

Frequently in watershed treatments, we find a condition that exhibits a trend with time. That is to say, watershed characteristics in relation to a treatment are in no sense static but are continuously recovering or deteriorating from a previous level. (For undisturbed watersheds the time trend is generally not significant.). It is the purpose of this discussion to illustrate a statistical method for establishing treatment effects with time.

Coweeta watershed No. 13 can be used to exemplify the method. It was completely clear-cut in the fall of 1939 and then allowed to grow back undisturbed until the present. The analysis of data in the 1951 Annual Report, SEFES, clearly indicates that changes in streamflow show some kind of a trend with time.

The 12 month streamflow data for the control watershed No. 18 and the treated watershed No. 13 are given in the following table.

Table II. - Streamflow from Coweeta Watersheds No. 18 & No. 13

Water Year May 1-April 30	Control W.S.#18 area - inches X_1	Treated W.S.#13 Y	Time in Years X_2
1936 - 1937	39.07	35.14	
1937 - 1938	31.24	28.69	
1938 - 1939	45.09	40.87	
Total Calibration Period	115.40	104.70	
Average Calibration Period	38.47	34.90	
1939-1940	21.10	30.16	1
1940 - 1941	17.84	26.57	2
1941 - 1942	31.70	40.14	3
1942 - 1943	44.67	51.67	4
1943 - 1944	37.13	42.84	5
1944 - 1945	26.26	32.27	6
1945 - 1946	44.43	51.26	7
1946 - 1947	30.68	34.11	8
1947 - 1948	40.96	44.49	9
1948 - 1949	65.39	64.80	10
1949 - 1950	46.42	47.00	11
1950 - 1951	32.50	36.59	12
1951 - 1952	46.27	46.20	13
Total Treatment Period	485.35	548.10	91
Average Treatment Period	37.33	42.16	7

The information desired from these data is to estimate the treatment effect for any given year in the period 1939 - 1952 with corresponding confidence intervals. The analysis can be carried out using multiple covariance analysis for two groups. This analysis will also provide a test for the significance of the treatment difference. See Snedecor pp. 350-354

Professor H. L. Lucas of the N. C. State College Department of Experimental Statistics has presented a method here illustrated in abbreviated form for handling the time trend in estimating treatment effects where a simplification of the problem results from the fact that it is not necessary to introduce the time variable in the calibration period.

For covariance analysis we would introduce a constant value of X_2 for all three years of the calibration period. For the calibration period the sums of squares and products are given below:

	X_1	Y
X_1	96.4571	84.5637
Y^1		74.2626

Then the regression coefficient of Y on Y_1 is given by

$$b_{y1} = \frac{84.5637}{96.4571} = 0.8767$$

For the treatment period the sums of squares and products leads to

	X_1	X_2	Y
X_1	1932.4837	357.4400	1558.0264
X_2		182.0000	218.3109
Y^2			1316.2262

where we have now introduced the time variable X_2, as shown in Table II. Solution of the normal equations gives us for the partial regression coefficient of Y

$$b_{y1.2} = 0.9177 \qquad b_{y2.1} = 0.6029$$

Note that the regression coefficients of Y on X_1 for the two periods, 0.8767 and 0.9177, are not significantly different, which should be the case if there is no time trend in the calibration period as assumed. Also, the test of significance for $b_{y2.1}$ is given by

$$t = \frac{-.6029}{\sqrt{.0155}} = -4.84 \text{ which is significant at the 1\% level for 10 D. F.}$$

We may now proceed to pool the information from the calibration and treatment periods with the resulting sums of squares and products as shown below. This is the same as the within line values obtained from the multiple covariance

	X_1	X_2	Y
X_1	2028.9408	357.4400	1642.5901
X_2		182.0000	218.3100
Y			1390.4888

Solution of the normal equations leads to the following values:

$$b_{y1.2} = 0.9148 \qquad b_{y2.1} = -.5971$$
$$s_y^2 = 18.2512 \text{ with } 12 \text{ D.F.} \quad \text{or} \quad s_y^2 = 1.5209$$
$$c_{11} = .0007536 \qquad c_{12} = .0014801 \qquad c_{22} = .0084013$$

We now have the following regressions for the calibration and treatment periods using the above and the means from Table II.

$$Y_c = 34.90 + .9148\ (X_{1c} - 38.47)$$
$$Y_t = 42.16 + .9148\ (X_{1t} - 37.33) - .5971\ (X_{2t} - 7)$$

For a common value of X_1 we obtain as the difference

$$Y_t - Y_c = 42.16 - 34.90 - .9148(37.33 - 38.47) - .5971(X_{2t} - 7)$$
$$= 8.30 - .5971(X_{2t} - 7)$$

and we can calculate the estimated increases in stream flow due to treatment for each year beginning with 1939-1940. For example, the estimated increase due to treatment $(Y_t - Y_c)$ for the fifth year after treatment would be 9.49 area inches.

To compute confidence limits for each estimate we derive the formula for the variance of the difference which is given by

$$s_d^2 = \text{Var}(Y_t - Y_b) = s_y^2 \left[\frac{1}{N_1} + \frac{1}{N_2} + c_{11}\ (\bar{X}_{1t} - \bar{X}_{2t})^2 + c_{22}(X_{2t} - 7)^2 \right.$$
$$\left. - 2c_{12}(\bar{X}_{1t} - \bar{X}_{2t})(X_{2t} - 7) \right]$$

Substituting values from above we arrive at

$$s_d^2 = 1.5209 \left[0.4112 + .008401\ (X_{2t} - 7)^2 - .0034(X_{2t} - 7) \right]$$

Thus for $X_{2t} = 5$ we find $s_d^2 = 0.6868$ and $s_d = 0.8287$

For 12 D.F., $t_{.05} = 2.179$ and the 95% confidence limit is ± 1.80 so that our estimate for the 5th year after treatment becomes

$$Y_t - Y_c = 9.49 \pm 1.80 \text{ area-inches}$$

The above procedures furnish a uniform method which can be used for the purpose of evolving a smooth trend curve for after treatment effects that are constantly changing. The method is proposed as being particularly useful in small watershed treatments. The Coweeta Staff would appreciate comments from specialists interested in the problem.

Use of Control Watershed Approach - Turbidity

In principle, the use of control watersheds should be applicable to any measurable variable on a watershed. Past quarterly reports have shown the application of the control watershed approach to total yield of water, maximum storm flow, and stream temperatures and discussed the problems involved with these variables. This discussion considers the use of the controlled approach with a fourth watershed variable, turbidity.

The south and north branches of Cold Spring Cove were sampled daily during the summer of 1947 for turbidity.

$$Y = 0.83 + .8296X$$

where X = turbidity in p.p.m., south branch
Y = turbidity in p.p.m., north branch

$r = .777^{**}$ $S_{y.x} = 2.56$ $S_b = .084$ C. V. = 34.92%

Although the coefficient of variation is high, a standard deviation of approximately 2.5 parts per million is well within the range of accuracy that is necessary for any proposed treatment that is envisioned at this time. As with the other watershed variables, adjacent watersheds of the same elevation produced better fits than watersheds that differed in elevation and location. Daily, weekly or monthly mean values of turbidity exhibit independence. Contrary to expectation, testing the turbidity values with Bartel's test for independence of data shows no indication of serial correlation.

One of the major problems encountered in applying the control watershed approach to turbidity centers around sampling methods. It must be remembered that turbidity measurements are instantaneous samples as compared with total or absolute values that can be obtained for other watershed variables. So far, we have only gathered daily or weekly samples taken at the same point in the stream at approximately the same time of day with the full realization that they do not represent the maximum effect of treatment.

Changes in Maximum Storm Peaks - Watershed No. 10

Flood control specialists have given considerable emphasis to the value of improved woodland management and logging methods in reducing storm runoff. References to their flood control values are made in the reports for the Pee Dee, Savannah and Delaware River watersheds among others. There is no denying that uncontrolled logging coupled with poor woodland management will cause increased storm runoff. But maximum storm peak data from watershed No. 10, a usual logging practice watershed, indicate that the changes in peaks brought about by this treatment are rather small when compared with changes in storm peaks associated with other phases of land use.

A study was made during the past quarter on the effect of common logging upon maximum storm peaks. Maximum storm peaks on the treated watershed No. 10 were compared with those occurring on control watershed No. 14 during the calibration period before treatment and a period bracketing

the heaviest logging activity. For high intensity summer storms, the results in Table 1 indicate that the rate of storm peaks increased adversely due to treatment.

Before treatment

$Y = 6.18 + .4762X$

$r = .9576^{**}$ $\quad S_{y.x} = 2.42$

where X = maximum storm peak in C.S.M., watershed No. 14

Y = maximum storm peak in C.S.M., watershed No. 10

After treatment

$Y = 9.09 + .7272X$

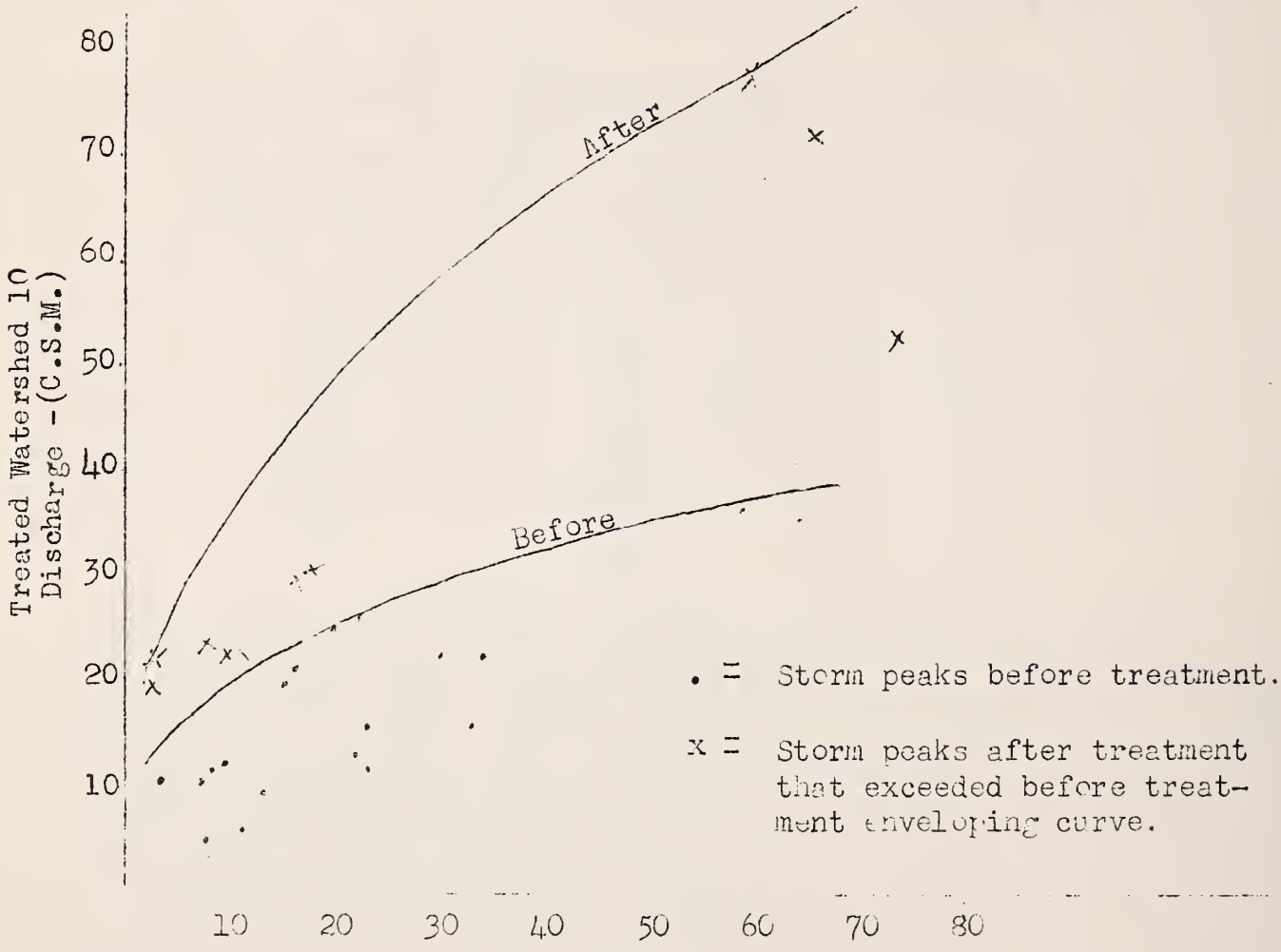
$r = .9571^{**}$ $\quad S_{y.x} = 4.44$

Table 1 - Maximum Storm Peaks from Control & Logged Watersheds.

Control Watershed 14 :	Treated Watershed 10	
	: Before Logging :	After Logging
(C.S.M.)	: (C.S.M.) :	(C.S.M.)
10	11	16
20	16	24
30	20	31
40	25	38
50	30	45
60	35	53
70	40	60
80	44	67

Maximum enveloping curves were constructed based on the extreme storm peaks, Fig. 1. The greater number of storms occurring in the "after" period that exceed the "before" curve are more than would be expected due to chance alone. None of the storms in the post treatment period exceeded 100 C.S.M. Are flood peaks of less than 100 C.S.M. on a 212 acre watershed important to flood control when badly used agricultural and grazing lands produced peaks as high as 1849 C.S.M. during the same period? Perhaps more emphasis should be placed on woodland management and logging methods from the standpoint of sedimentation and water quality rather than reduction in runoff.

Figure 1
Maximum Enveloping Curves for
Storm Peaks
Before and After Treatment



Hydrograph Analysis - Stormflow and Ground Water Runoff

The undisturbed, deep soils of forested areas that have a very high surface and good internal drainage exerts a marked regulatory influence how rainfall is finally delivered as streamflow. One of the essentials for indicating this regulatory effect is that the stream-hydrograph be separated into groundwater flow and the several components of stormflow. Little data have been available for the Coweeta watersheds on the components of a stream hydrograph to all storms extending over a period of several years. A study was made this quarter by using a discharge flow integrator on all storm hydrographs from Coweeta W. S. 13 for the period from 1936 to 1952, inclusive.

The technique for separating the storm hydrograph is described in the article by Hursh and Brater, Methods Section, on page 863, 1941 issue American Geophysical Union.

Table III - Annual Precipitation and Runoff, Coweeta Watershed 13.

Water Year	Gross Precip.	Runoff 1/ Total	Stormflow	Groundwater
	In.	In.	In.	In.
1937	71.47	35.13	2.95	32.18
1938	63.30	28.69	2.32	26.37
1939	73.06	40.86	3.49	37.37
1940	57.17	30.15	3.47	26.68
1941	50.56	26.56	1.25	25.31
1942	72.97	40.15	2.87	37.28
1943	77.69	51.67	5.78	45.89
1944	68.50	42.84	3.38	39.46
1945	64.16	32.27	2.18	30.09
1946	79.50	51.26	5.07	46.19
1947	68.29	34.09	3.37	30.72
1948	73.62	44.49	4.31	40.18
1949	108.08	64.80	7.24	57.56
1950	75.21	47.03	3.72	43.31
1951	65.35	36.60	2.01	34.59
1952	71.20	46.20	4.17	42.03
Average	71.26	40.80	3.60	37.20

1/ includes channel precipitation and subsurface stormflow.

Variation from year to year of stormflow is governed by the number of large storms that have occurred. For example, storms in November 1948 produced 2.11 inches and March 1952, 2.15 inches of stormflow. In general the annual stormflow on watershed 13 is 3.6 area inches and has varied from 1.2 to 7.2 area inches. Expressed as a percentage of precipitation, annual stormflow has varied from 2.5 to 6.4 with an average of 5.2 percent.

Table IV - Average Monthly Precipitation and Runoff (Period March 1936 - October 1952), Coweeta Watershed 13.

	Runoff				
	Storm-flow 1/	Groundwater	Total	Gross Precipitation	Storms
	in.	in.	in.	in.	No.
Nov.	.29	1.85	2.14	5.14	7.5
Dec.	.45	2.63	3.08	7.16	8.5
Jan.	.52	3.92	4.44	6.98	9.5
Feb.	.49	4.60	5.09	7.10	9.3
Mar.	.56	5.46	6.02	7.90	10.5
Apr.	.29	5.20	5.49	5.78	8.9
May	.12	3.66	3.78	4.41	12.1
June	.16	2.57	2.73	5.22	14.4
July	.21	2.21	2.42	6.82	15.8
Aug.	.24	1.89	2.13	5.91	15.3
Sept.	.18	1.72	1.90	4.75	8.6
Oct.	.15	1.50	1.65	4.11	7.5
Total	3.66	37.21	40.87	71.28	128

Average monthly stormflow is greatest during December to March, the period when large storms usually occur. During this winter period even though groundwater elevation and soil moisture levels are high, there is still adequate storage in the forest soil profile in delaying the transfer of rain to stormflow and converting it to regulated ground water flow. During the growing season the storms are small, which accounts for the low values of 0.15 to 0.20 inches stormflow.

Data from this study when compared with information on other streams suggest the magnitude of stormflow on forested headwater drainages is rather similar as shown in Table V.

Table V - Precipitation and Runoff for Selected Forested Watersheds in the Southern Appalachian Mountains.

	Area	Gross	Runoff			
Watershed	Acres	Precip.	Total	Stormflow	Groundwater	Period
		in.	in.	in.	in.	
Coweeta 8	1877	44.45	32.43	4.09	28.34	11/36-4/37
Coweeta 9	1788	49.20	35.46	4.50	30.96	" "
White Hollow (Tennessee)	1715	33.61	15.95	6.15	9.80	" "
Coweeta 13	40	71.26	40.87	3.66	37.21	1937 - 1952
White Hollow (Tennessee)	1715	45.16	16.84	5.62	11.22	1945 - 1949

It is evident that the large differences in total flow among forested streams may be accounted for by lower base flow.

It is recognized that more data must be processed from watersheds having different acreages, land use, and topographic characteristics.

Also further analysis work is necessary on the study of separating runoff into stormflow and groundwater. Experience this quarter indicated considerable progress can be made in this field through use of a discharge flow integrator.

Hydrologic Notes

Air temperatures were close to normal for the quarter. The first frost at the valley floor was recorded on September 14. October had numerous minimums below 32°.

Precipitation was normal when considering the entire quarter but its occurrence was spotty. October was characterized by extremely dry conditions, a deficit in precipitation having been carried over from the previous quarter.

Early October produced a record number of cloudless days for this section of the country. Eight continuous days of clear skies other than for the usual morning fogs were observed.

Ground water well No. 14, our indicator of fall soil moisture conditions, did not begin to rise until December 9. The rise in ground water was preceded by about 9.5 inches of rainfall within a two-week period.

Climatic Summary of Air Temperature and Evaporation

Month	Average		Maximum		Minimum		Evaporation	
	17-Yr. °F	1953 °F	17-Yr. °F	1953 °F	17-Yr. °F	1953 °F	17-Yr. in.	1953 in.
October	56.1	55.9	70.9	72.4	41.3	39.4	2.55	2.94
November	45.3	44.2	58.8	60.5	31.6	27.9	1.71	1.65
December	39.6	37.8	51.5	49.6	27.4	25.9	1.03	0.99

Quarterly Precipitation Summary

Month	17-Yr. Average In.	1953 In.	Deviation from Average In.	No. of Storms 17-Yr. Average	No. of Storms 1953
October	3.59	1.11	-2.48	12	3
November	5.26	4.47	-0.78	6	2
December	6.45	9.60	+3.15	9	9
Qtrly. Total	15.30	15.18	-0.11	27	14
Water Yr. to Oct. 31	69.85	65.76	-4.09		
Calendar Yr. to Dec. 31	69.85	67.21	-2.64		

Cooperation

North Carolina Wildlife Resources Commission
U. S. Fish and Wildlife Service

The fish biologist spent the past quarter in routine bottom sample collections and the remainder of the time in identifying the large backlog of bottom samples and stomach fauna. The data is being analyzed at present.

Robert E. Stevens, fish biologist, has been assigned to the D-J project at Coweeta for the winter months. Bob's assignment here is a part of the Wildlife Resource Commission's training program to acquaint him with fisheries problems and the division's program in the Coastal Plains, Piedmont and Mountains.

Universities

"The Effects of Clear-Cutting Forest Vegetation Without Removal and Subsequent Annual Cutting of Regrowth Upon Some Pedologic and Hydrologic Characteristics of a Watershed in the Southern Appalachians"- F. D. Freeland, Jr.

Laboratory determinations were made during this past quarter on volume weights and porosities from soil samples collected during the summer months.

An initial soil survey was made on watersheds No. 17 and No. 18 to determine the range of variation of soils and sites within the watersheds. With these survey data the two watersheds were classified into three general soil-sites, which were well represented on both watersheds. On each watershed three index stations were chosen within each soil-site; thus there are a total of 18 index stations on the two watersheds.

Volume weights, total porosity, and capillary and non-capillary porosity values for watershed No. 17 are shown in Table VI.

The soils within watershed No. 17 are much more uniform with regard to volume weight and porosity than was anticipated. Data from watershed No. 18 also indicate a surprising uniformity in these characteristics between sites.

Analyses are being made during the winter quarter on soil permeability, mechanical analysis, aggregate analysis and soil organic content.

Table VI - Summary of some physical characteristics of the soil for Watershed No. 17

Depth	Volume Weight	Porosity		
		Total	Capillary	Non-capillary
		Percent	Percent	Percent
DEEP, LOAM TO CLAY LOAM SOILS WITH HIGH ROCK CONTENT, COVE SITES				
0-3 inch layer	0.85	62.2	31.2	31.0
3-6 inch layer	1.02	58.5	31.6	26.9
12-15 inch layer	1.30	51.1	32.8	18.3
30-33 inch layer	1.35	51.2	32.1	19.1
DEEP LOAM TO CLAY LOAM SOILS WITH HIGH ROCK CONTENT, MIDDLE AND LOWER SLOPE SITES				
0-3 inch layer	0.92	61.3	32.8	28.5
3-6 inch layer	1.02	58.3	33.5	24.8
12-15 inch layer	1.12	56.6	29.6	27.0
30-33 inch layer	1.37	51.1	30.7	20.4
MEDIUM DEEP, LOAMY SAND TO LOAM SOILS WITH LESS ROCK, UPPER SLOPE & RIDGE SITES				
0-3 inch layer	0.99	57.4	30.2	27.2
3-6 inch layer	1.07	57.4	32.8	24.6
12-15 inch layer	1.30	52.5	27.2	25.3
30-33 inch layer	1.48	46.5	27.9	18.6

North Carolina State

The Forestry Department of North Carolina State College has completed arrangements with the Pisgah National Forest for the use of Wayah Depot as a summer camp. Present plans indicate that a portion of the student field work in connection with the summer camp will be at Coweeta.

National Forest Administration

A two-day training session on water resource management was held during the quarter for 15 professional foresters from Region 7 and the Northeastern Forest Experiment Station. The Allegheny, Green Mtn., and White Mtn. National Forests and Bartlett Experimental Forest were represented.

Visitors

Sixteen organized groups visited Coweeta during the quarter with a total of 90 visitors. This brings the total for the calendar year to 75 groups with 864 visitors.

Publications

Dils, R. E. 1953. Influence of Forest Cutting and Mountain Farming on Some Vegetation, Surface Soil and Surface Runoff Characteristics, Southeastern Forest Experiment Station, Station Paper No. 24, 55 pp.

Anon. 1953. Woods Grazing May Be Bad. Progressive Farmer.(Ga.-Ala.-Fla. Edition), Jan. 1953, ill.

Addresses

Ed Johnson has had to work for his supper in recent months. First appearance was at a dinner meeting of the Haw Creek Lion's Club. Then he spoke before the monthly meeting of the Buncombe Public Health Department in Asheville. Next, Regional Forester Connaughton and Ed spoke at a banquet in Clayton, Georgia, for the Business and Professional Women's Club of Atlanta. Finally, he spoke at a luncheon meeting of the Georgia Engineering Society in Atlanta on the subject "The Water Shortage - Is There an Answer?"

In addition to these addresses, Ed presented a paper before the Division of Watershed Management at the S.A.F. annual meeting, Colorado Springs. His paper was entitled "Changes in Streamflow Characteristics Brought About by Cutting Forest Vegetation.

QUARTERLY PROGRESS REPORT

July - September 1953

PIEDMONT RESEARCH CENTER 1/

Effect of Prescribed Burning on Piedmont Soils

In preparing a study to investigate the effect of prescribed burning on forest soils, plans were made for some infiltration tests. The purpose of the infiltration runs is to find the effect of litter quantity and quality on runoff and soil movement. From the study it is hoped we can determine which combinations of fire and forest floor (or humus type) are detrimental to the site from the soils standpoint.

Infiltration runs are ordinarily made with the simulated rain having a drop fall of 7 feet. Since raindrops reach their terminal velocity when they fall about 23 feet, the question arises as to whether a drop fall greater than 7 feet might not more effectively reproduce nature.

Although it is known that the velocity of the drop and its stored energy increases with height of fall up to 23 feet, perhaps the forest floor functions well enough as a sponge so that the effect on the underlying mineral soil is the same regardless of the distance the rain falls. To test this, rain was applied from heights of 7, 14, and 23 feet to a uniform soil mass covered with varying quantities of pine needles.

So that constant intensities could be produced, it was necessary to have the raindrops fall in still air. A wooden structure about 23 feet high and 4 feet square was made of lumber and placed inside the legs of a fire tower. Water was applied with two or three regular forest service type F nozzles.

Small metal pans, 8 x 14 x 1-1/2 inches in size, with a small drain spout at one end, 1/2 inch from the pan bottom, were used in the tests. The bottom was solid and was covered with a half-inch of mineral soil when making tests. Soil was covered with loblolly pine needles in quantities ranging from 0 to 4000 pounds per acre, in 500 pound increments. The soil in the pans was wet to field capacity, the pan tilted at a 10 percent angle, and artificial rainfall applied for 30 minutes at an intensity of about 3 inches per hour. Intensity was measured by collecting rainfall in small cans for two 10-minute intervals.

1/ Joint projects of the Divisions of Forest Influences and Forest Management.

At various times raindrop samples were collected to see if the drop size varied between the various heights of fall, and to see how much they differed from natural rainfall. From data collected so far there appears to be no appreciable difference in drop size distribution. The raindrops were collected in sifted flour, The flour was exposed to rain for a few seconds and where drops hit, small pellets formed. After air drying the pellets were removed from the flour mass and oven dried. Dry pellets were sorted by size and weighed. A previously determined ratio between the mass of the raindrop and the flour pellet was then used to calculate the size of the raindrops.

A rubber tube connected to the pan spout led to a 4-liter glass jug in which runoff water was collected. Runoff water was measured and the soil in it precipitated with alum. The water was then filtered and the weight of soil in the runoff water was determined. The pans of soil were then oven dried and weighed (without litter) and the difference between this and initial weight gave the total soil loss. The difference between the total soil loss and that in the runoff water is considered as loss in splash.

Obviously, more soil is going to be moved from the bare soil than the covered soil. One of the objectives of the tests was to determine that weight of forest floor at which the quantity of soil moved increased appreciably. For the tests under conditions as described above, the critical weight of forest floor is about 2000 pounds per acre. That is, there is a sharp increase in quantity of soil moved when less than 2000 pounds per acre of material is present. This held for three drop falls and for the three types of soil loss. It was most pronounced in soil moved in splash and total soil moved.

As the height of drop fall increases, up to 23 feet, the quantity of soil moved increases. As the quantity of material protecting the soil surface increases, the quantity of soil moved decreases. From what is known about the energy in raindrops, it does not appear that increasing the drop fall over 23 feet would appreciably change its soil-moving power.

Since the amount of soil moved from the pans appeared to be correlated with drop height regardless of quantity of surface cover, regression equations were derived so that soil moved from 14 and 23 feet falls could be estimated when that moved with the 7-foot fall is known. All equations

were highly significant and a summary is given below.

Comparisons of soil moved at 7, 14, and 23 feet drop falls. The values given are approximately the b_1 coefficient of the equations.

Total soil moved

Soil moved with 14' drop fall is 2.0 times that of 7' fall

Soil moved with 23' drop fall is 2.5 times that of 7' fall.

Soil moved in splash

Soil moved with 14' drop fall is 2.1 times that of 7' fall.

Soil moved with 23' drop fall is 2.7 times that of 7' fall.

Soil moved in runoff water

Soil moved with 14' drop fall is 1.6 times that of 7' fall.

Soil moved with 23' drop fall is 1.5 times that of 7' fall.

Before a final decision is made as to which drop fall height to use in the field, further tests will be made. We plan to make field tests with different drop fall heights to see if the above correlations hold. There is also a need for more sampling of raindrop size to see how storms of different intensities compare with the artificial rainfall.

Climatic Conditions

This quarter was characterized by the driest November in the past seven years. The month of October was the second driest for the same period of time. However, the lack of precipitation during October and November was offset by the wettest December in the history of the Calhoun Experimental Forest. The precipitation data for these months are shown below.

Climatic Summary - Calhoun Experimental Forest

Month	Average Temperatures			Highest Temp.	Lowest Temp.	No. of days with rain	Precip.	Evap.
	Max.	Min.	Mean					
	°F	°F	°F	°F	°F		Ins.	Ins.
October	77	47	62	87	31	3	.81	3.297
November	66	33	50	82	15	4	.54	2.165
December	54	31	43	67	5	17	7.92	1.561

Temperatures for October and November were about average, while temperatures for December were a little below normal with a record low temperature of 5°F. established on December 18.

Total precipitation for the calendar year was 48.42 inches which was 7.73 inches above the 1952 total precipitation and 0.81 inch above the average annual precipitation.

General

Marvin D. Hoover, Research Center Leader, transferred on November 1 to the Rocky Mountain Forest Experiment Station as Chief of the Division of Watershed Management.

Haney and Metz spent two days at a Littleleaf Conference with members of the Regional Office and the South Carolina National Forests. Part of one day was spent on the Calhoun Experimental Forest looking at littleleaf areas.

Plans were drawn up by Metz for a cooperative study with the South Carolina Forestry Commission. The study is concerned with when and how much water to apply to the nursery beds with the sprinkler system.

Metz attended the Soil Science Society of America meeting at Dallas, Texas, and presented a paper, "The Forest Floor of the Piedmont Region."

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
January - March 1953

DIVISION OF FOREST INFLUENCES

SUMMARY

The amount of rain caught in tilted gages differs from the amount caught in vertical gages but the difference may be either plus or minus. Studies have just been started directed toward finding out the reasons why this is the case. Page C-2.

Research that requires the standardization of a watershed upon itself has presented some complex problems of methodology. An important step forward was made during the last quarter by making use of the Coweeta concept of the hydrologic year May 1 to April. It was discovered that by using only total records of rainfall and runoff for this hydrologic year it is possible to standardize certain watersheds within five years and provide a test of significance of worthwhile differences in water yield down to approximately 10 percent of the annual mean. Using a control watershed design, however, tests are made down to 3 percent. Page C-3.

Tom Nelson shows that the consistent behavior of Coweeta watersheds in functioning as detention reservoirs is further demonstrated by multiple regressions for predicting runoff. Page C-4.

Kovner demonstrates that the Gumbel's theory of the recurrence of annual flood peaks can be applied to Coweeta data. Page C-5.

Field moisture saturation deficit during the growing season is greater under pine plantation than under broomsedge. Page C-13

Report on shortleaf pine seed production. Page C-15.

ASHEVILLE

A symposium on "Current Problems in Conservation" was held February 12, in the Moot Court Room, College of Law, on the campus of the University of Tennessee, Knoxville. The symposium was sponsored by the East Tennessee Chapter of the American Society for Public Administration together with the Political Science Department and the Botany Department of the University. Hursh represented the Station as one of the panel of speakers. He developed the subject of "Watershed Management in Headwater Areas." Greatest interest in this subject centered about the comparative effectiveness of forest and pastures in the control and storage of storm water.

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT

January - March 1954

COWEETA HYDROLOGIC LABORATORY

Vertical and Tilted Rain Gages

Standard U. S. Weather Bureau rain gages are used to record precipitation in the Coweeta rain gage network. The orifice of this gage is horizontal. One of the common questions raised from time to time is whether tilted gages with the orifice parallel to the land slope would not give a more accurate measurement of rainfall. Consequently, from time to time tests with different types of gages are tried out under different conditions. The most recent tests using 8 tilted gages were carried out during the past quarter.

Table 1 shows the comparison of catch for 10 storms ranging in size from 0.25 to 3.77 for two gages operated on different facing aspects. The table shows that differences can be obtained between vertical and tilted gages but that these differences can be either a plus or minus. Further records will be taken before a conclusion will be drawn. Preliminary indications are that the direction of the prevailing rain or even the direction of the wind during the storm can be more significant than the slope of the land. If this is the case, then a gage tilted away from the wind catches less rain and a gage tilted into the wind catches more than a vertical gage. The U. S. Weather Bureau was obliged to consider all the possibilities fifty years ago and came to the final conclusion that for all practical purposes the standard vertical gage with a horizontal orifice gave the most accurate and consistent year-round records of rainfall.

Table 1.--Comparison of total precipitation recorded in vertical and normal gages

Station	Aspect	Slope of orifice	Ten storm total catch		Difference Vertical - Tilted	
			Vertical	Tilted	Amount	Percent
		Percent	Inches	Inches	Inches	Percent
A	N40W	63	14.15	13.81	+0.34	+2.5
B	S50W	44	10.31	10.58	-0.27	-2.6

Watershed Standardization

Studies carried out this quarter suggest it is possible to standardize a watershed on itself and test the significance of worthwhile differences in runoff down to approximately 10 percent of mean runoff using only total 12 months' records of rainfall runoff. For Coweeta conditions, May 1 to April 30 rainfall-runoff relation adjusted for ground water in storage provides the most workable basis for standardizing a watershed. At the beginning of the period field moisture is about the same each year. Rainfall-runoff relations are consistent notwithstanding the wide ranges of annual precipitation (47-90 inches). Using the May 1 - April 30 water year, and provided there is the usual range of climatic conditions during the five-year period, we find that a watershed at Coweeta can be standardized on itself in approximately 5 years, Table 2. At present, the method provides a tool for estimating changes of around 10 percent in annual runoff. Using control watershed we can test for differences down to 3 percent of the mean annual water yields and work with runoff for any period, that is, days, months, seasons, etc.

Table 2.--Rainfall-runoff standardization for selected Coweeta watersheds. Water year May 1 - April 30

WS	No. of yrs.	Average Precip.	Average 1/ Runoff	Coef. of correlation	Exp. variance	Smallest worthwhile treatment diff. 2/ In.	Smallest worthwhile treatment diff. 2/ % of mean RO	Linear regression for adj. runoff
		In.	In.					
1	7	63.34	24.85	.983	3.47	3.12	12.5	RO = .947P-44.60
2	17	69.33	29.28	.979	7.94	3.34	11.4	RO = .912P-34.03
6	6	78.64	38.06	.992	1.82	2.76	7.2	RO = .853P-29.03
19	5	79.68	49.96	.977	2.63	2.56	5.2	RO = .892P-21.14

1/ Runoff adjusted for year-end ground water storage.
2/ An arbitrary 5-yr. treatment period has been used.

Multiple Regressions for Predicting Runoff

Most hydrologic phenomena are products of multiple causation. Monthly and seasonal runoff are associated with several variables, antecedent in time, among which are accumulated precipitation, ground-water and temperature. As a phase of water balance studies on individual watersheds, multiple regressions were tested on 18 years of data for Watershed No. 2 in an attempt to provide another expression of the regularity of behavior of a well-forested watershed. Five-factor linear multiple regressions were calculated using various periods of antecedent and current precipitation, ground-water storage, and air temperatures as independent variables and runoff as the dependent variable.

After elimination on non-significant variables, the linear regression for each month during the winter season of ground-water recharge reduced itself to:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3$$

where Y = current monthly runoff in inches

X_1 = storage at beginning of previous month in inches

X_2 = storage at end of previous month in inches

X_3 = precipitation during current month in inches.

During the growing season and fall months of soil moisture recharge, the 30-day antecedent storage factor (X_1) did not materially improve the fit, and this variable was eliminated from the regression. The standard error of estimate for months in the period of ground-water recharge averaged less than .75 area inches with coefficients of variation ranging from 19 to 24 percent. During the other hydrologic seasons, the standard error of monthly runoff was in the neighborhood of .41 inches, and the coefficients of variation were the same as those obtained for the ground-water recharge period. The coefficients of the precipitation and storage factors followed a monthly trend, e.g., as would be expected, the monthly precipitation had less effect on the monthly predicted runoff for each successive month of the growing season.

Multiple regressions calculated with total seasonal runoff as the dependent variable showed a better coefficient of variation than did the monthly values. The regressions are shown below:

Hydrologic Season	Formula[1]	R	C.V.
Jan.-April	$Y = -7.71 + .5429X_1 + .7836X_2 + .4628X_3$	.9444	14.9%
May-Sept.	$Y = -8.39 + 1.2231X_1 + .4363X_2$	.9220	19.5
Oct.-Dec.	$Y = -1.25 + 1.0790X_1 + .1940X_2 + .0922X_3$	.9508	11.6

1/ Y = current seasonal runoff in inches
X_1 = storage at time of previous hydrologic season in inches
X_2 = precipitation in inches for current hydrologic season
X_3 = precipitation in inches for preceding hydrologic season.

The addition of known variables would probably reduce the unexplained variation. For example, soil moisture measurements would certainly improve the relationship. However, even though there is considerable unexplained variation in the present formulae, it is felt that multiple regressions can provide us with another tool to aid in the best expression of major causal factors and the significance of their relationships in water balance studies.

Annual Floods

The annual flood is the largest instantaneous peak discharge of flow that occurs within a 365-day period. Various statistical methods have been devised for analyzing a set of annual flood values extending over a period of years in order to predict the behavior of annual floods of a given time. The most successful method to date has been developed by E. J. Gumbel based on his asymptotic theory of extreme values. These extreme values may be the set of smallest or largest recorded flows. Studies this quarter showed that annual floods from small forested headwater areas in the Southern Appalachians may be analyzed by the extreme value theory of Gumbel.

Eighteen years of data from a 152-acre forested watershed have been analyzed. None of the annual floods listed in Table 3 have been particularly damaging on this watershed. During the three largest floods some damage to roads on the Laboratory occurred because of inadequate culvert capacity, and weir blade capacity was exceeded on a few watersheds.

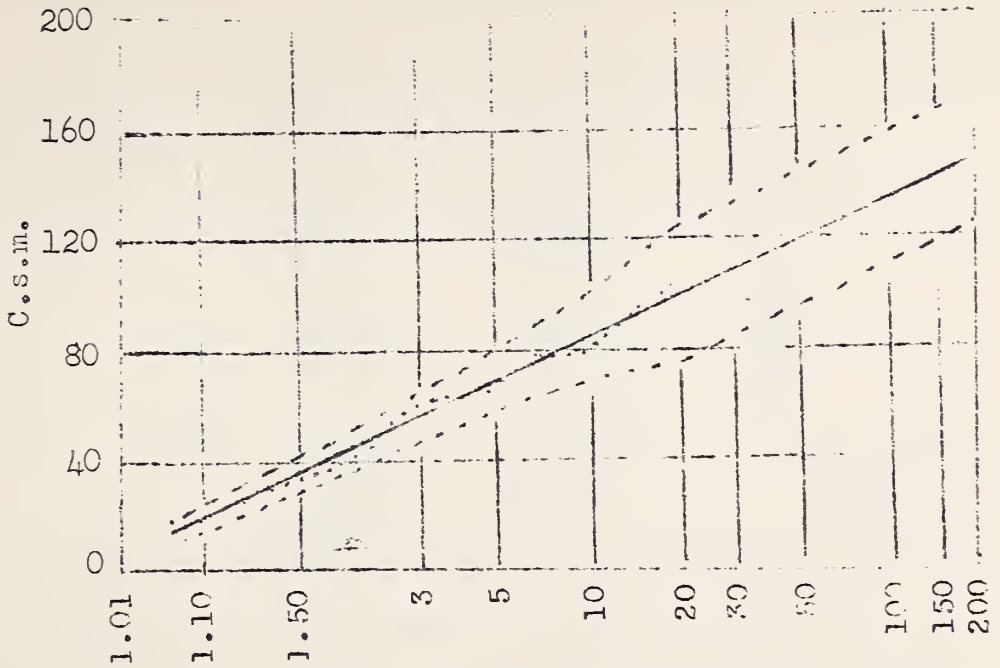
Table 3.--Annual floods - WS #14, Coweeta Hydrologic Laboratory
1936-1953 - water year Nov. 1-Oct. 31

Rank	Annual flood	Recurrence interval
	c.s.m.	Years
1	16.85	1.06
2	22.73	1.12
3	25.39	1.19
4	28.22	1.27
5	28.51	1.36
6	32.16	1.46
7	33.45	1.58
8	34.41	1.73
9	38.14	1.90
10	41.61	2.11
11	49.44	2.38
12	58.69	2.72
13	60.24	3.16
14	60.71	3.80
15	63.73	4.74
16	74.87	6.33
17	75.38	9.52
18	101.74	18.87

Data from Table 3 is plotted in Figure 1 on Gumbel's extreme probability paper with the dotted line connecting the plotted points. The straight line has been fitted by least squares according to the extreme value theory. The lines on either side of the straight line are the 0.68 confidence interval.

The analysis can be used for several purposes. For example, the capacity of the 120° V-notch weir on Watershed No. 14 is 134 c.s.m. Extrapolation shows that this flood is expected to occur within 110 years and the probability is 2/3 that it will occur within the interval from 30 to 500 years. For experimental purposes, the capacity of the weir blade is adequate. On the other hand, the line confirms the fact that a 90° V-notch blade with a capacity of 70 c.s.m. would be exceeded on the average of once every 5.5 years and hence would not be satisfactory for this watershed. Actually the 120° V-notch replaced the original installation which was a 90° blade. Together with a similar analysis for minimum flows, the results would be useful in weir design.

Fig.1-Annual Floods on Watershed 14
Drainage Area 152 Acres - Period 1936-53



Recurrence Interval in Years for Annual Floods

Another example is to estimate the 50-year annual flood in connection with the construction of bridges and installation of culverts. Actually, information is meager on the capacity of such structures in forested headwater areas for the desired life of an access or logging road. Figure 1 shows an estimate of 120 c.s.m. for the 50-year annual flood on areas comparable to Watershed No. 14.

Hydrologic Notes

Heavy rains in January largely accounted for the 6.2 inches excess of precipitation above normal. Major storms occurred on January 15-16 and 21-22, amounting to 4.71 and 6.19 inches, respectively, at the administration area. Streams on Coweeta remained within their banks, but the Little Tennessee went out of its banks on both occasions and flooded adjacent bottomland. No serious damage was reported.

Table 4.--Quarterly precipitation summary

Month	1954	Dev. from normal	No. of storms	
			1954	Dev. from normal
	Inches	Inches		
Jan.	12.34	+5.01	5	-6
Feb.	7.21	+0.35	7	-1
Mar.	8.71	+0.85	6	-2
Qrtrly. Total	28.26	+6.21	18	-9
Water Yr. to 3/31	43.44	+9.68		
Cal.Yr. to 3/31	28.26	+6.21		

The precipitation for the calendar year of 1953 has been computed

Description of catch	S.R.G. No.	Annual recorded precipitation
		Inches
Minimum	32	58.77
Maximum	8	93.50
Average Max. & Min.		76.13
Average 71 gages		75.16

Two rain gages in the Coweeta network, Nos. 32 and 8, have consistently recorded the maximum and minimum amounts of precipitation respectively during 18 years of records. No. 32 is located on the northeast boundary and No. 8 close to the southwest boundary. Thus, there is a range of 35 inches in the total annual precipitation on the area taking place within a two-mile distance, and a relief of 700 feet. Although there is a considerable range in the total amount, the average of the maximum and minimum readings agrees very closely with the arithmetic average of all 71 gages on the area.

Evaporation data during late fall and winter periods are not always directly comparable from year to year due to variability in number of days with ice formation in the pan. Several daily January 1954 evaporation records were lost due to a four-day period of ice followed by a rain which caused the pan to overflow.

Table 5.--Climatic summary of air temperature and evaporation

Month	Average		Maximum		Minimum		Evaporation	
	1954	Dev. from normal	1954	Dev. from normal	1954	Dev. from normal	1954	Dev. from normal
	°F	°F	°F	°F	°F	°F	In.	In.
Jan.	40.6	+0.4	53.8	+2.7	27.4	-1.9	--	--
Feb.	42.9	+1.9	56.8	+3.8	29.0	+0.1	1.85	+ .18
Mar.	45.3	-1.6	58.0	-1.9	32.6	-1.3	2.63	- .19
Aver.	42.9	+0.2	56.2	+1.5	29.7	-1.0	2.24	--

Ground Water

Continued normal precipitation in February and March has brought soil moisture, ground water, and streamflow to normal spring levels.

The rise in ground-water levels began in November 1953, and continued during this quarter in response to recharge by the heavy January precipitation. Ground water well No. 14, a good indicator of the valley water table, reached its maximum rise January 15th.

Periods without rain in February created ideal soil conditions for plowing and disking, and many local farmers took advantage of the situation.

Cooperation

N. C. Wildlife Resources Commission:--Cooperative studies on trout habitat have been in progress since July 1952. The field work for the original studies of bottom fauna has now been completed and a report is in progress. A second study on the effect of introducing limestone gravel into the stream to change acidity is still in progress. These studies are in cooperation with the U. S. Fish and Wildlife Service and Fresh Water Division, N. C. Wildlife Resources Commission, provided for by Dingell-Johnson funds assigned to the State of North Carolina. Reorganization in the State Fresh Water Division now makes it necessary to reassign the cooperating fish biologist, Mr. L. B. Tebo, to the position of fish biologist on one of the eight newly established state districts. It is expected that Mr. Tebo, although located at other headquarters, will maintain close contact with the continuing studies.

Universities:--Kenneth A. Pitcher, recently graduated from Colorado A&M, arrived at the end of March on a cooperative aid project with North Carolina State College. His assignment will lead to the completion of a Master's thesis. Pitcher worked as a field assistant with the Manitou Experiment Station during the summer of 1952.

Information & Education

Several requests were answered during the quarter for plans, specifications and cost estimates for constructing different types of stream gaging stations. These requests were in connection with the Department of Agriculture's new pilot watershed projects.

A two-day training session was provided for students taking the Forest Influences course at Alabama Polytechnic Institute, Auburn, Alabama. This two-day intensive training session provided by the Coweeta staff is substituted for time normally spent on laboratory problems.

The General Federation of Women's Clubs of America are conducting a nation-wide essay contest on water and watershed management. The Clayton Club has submitted one essay on Watershed Management, based on the Coweeta Hydrologic Laboratory.

The Franklin, North Carolina, Chamber of Commerce prepared a brochure to encourage new industries in the County. The Station was called on to furnish sources of information, and data on streamflow, water quality, ground water and climate. One of the main points stressed in the brochure is the availability of ample supplies of high-quality water.

Information was sent to the Asheville Citizen-Times in response to a request for material on water resources of western North Carolina.

Visitors

The first quarter of the year generally provides a breather from the heavy visitor schedule. Only fifteen people were shown the area.

An interesting visitor was Frank A. Loyd, District Commissioner, Fort Hall, Kenya, East Africa. Mr. Loyd's trip was sponsored by the Commonwealth Foundation. His principal interests are organized land use planning.

Publications

The Department of Agriculture has issued pamphlet A.I.B. 117, "Waters of Coweeta." It is designed to highlight the results of 20 years of streamflow studies at Coweeta, borrowing text and pictorial illustrations from the documentary film, "Waters of Coweeta."

Rex L. Bird, of the North Carolina Wildlife Resources Commission, presented a mimeographed report to the Seventh Southeastern Wildlife Conference, Chattanooga, Tennessee, October, 1953, entitled "Observations on Altitudinal Tolerance of the Multiflora Rose." The planting tests were originally carried out at Coweeta in 1950. The author concluded that plantings were successful below 3000 feet, but above that elevation must be attended by proper culture and located in full sunlight in order to be successful. A supply of mimeographed copies is available at Coweeta.

NELSON, T. C. and JOHNSON, E. A.
Applying Unit Area Control to Watershed Management.
Jour. of Forestry, 52 (2), February 1954.

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
January - March 1954

PIEDMONT RESEARCH CENTER 1/

Climate

The weather this quarter was both wet and dry. The 6 inches of precipitation recorded in January is the most we have recorded for that month and about twice the 50-year average. The amount which fell during February was about one-half that of the average and the March precipitation was the same as last year and about an inch above the average.

Climatic Summary - Calhoun Experimental Forest

Month	Average temperatures			Highest Temp.	Lowest Temp.	No. of days with rain	Precip.	Evap.
	Max.	Min.	Mean					
	°F.	°F.	°F.	°F.	°F.		Inches	Inches
January	56	31	44	74	13	10	6.03	1.712
February	62	32	47	77	17	5	2.32	2.653
March	64	38	51	84	15	11	5.42	3.860

Soil Moisture

The withdrawal of water in the soil mantel is greatly influenced by the vegetation growing on the site. One of the most important factors involved is the rooting habit of the species present. This is shown with Figure 1, on which total moisture in the surface 66 inches of soil is plotted over time for a young pine plantation and a broomsedge field.

When the growing season starts, the vegetation begins to withdraw moisture from the soil and this continues throughout the growing season. The amount of water removed by the pine is appreciably more than that removed by the broomsedge. The interesting point is from which part of the soil profile this moisture comes. In the plantation the moisture is withdrawn throughout the whole soil depth whereas under the broomsedge the water

1/ Joint projects of the Divisions of Forest Influences and Forest Management

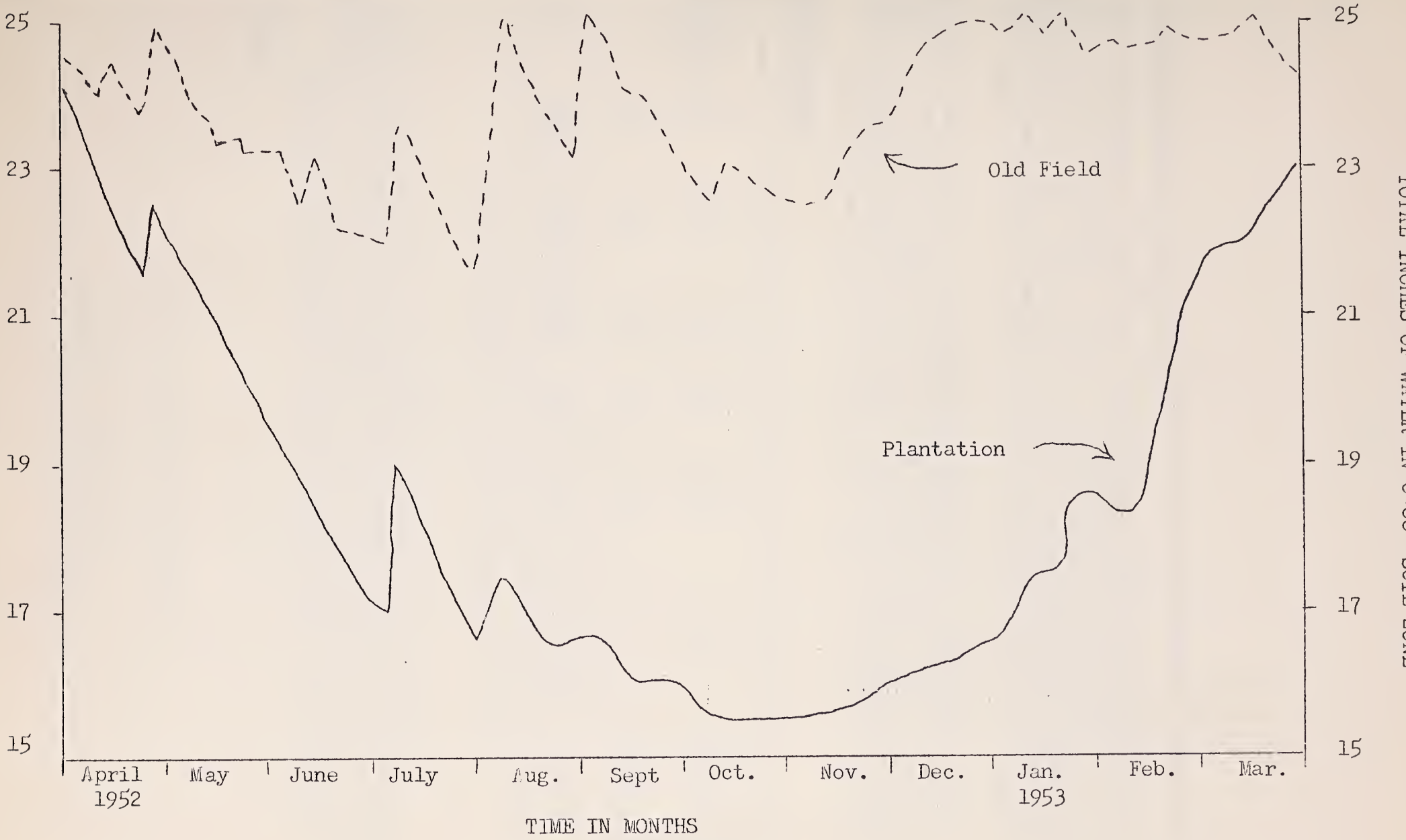


Fig. 1. Total soil moisture in surface 66" of soil beneath a young pine plantation and a broomsedge field.

is withdrawn only from the surface 30 inches. The data listed in table 1 make it quite apparent that the roots of the pine permeate the whole 66 inches layer of soil while those of the broomsedge are confined mostly to the surface 30 inches.

In figure 1 there is a sharp increase in soil moisture in both profiles around July 1 due to a rain of about 3 inches. This rain added moisture to the soil in the top 30 inches only. During and after this storm the quantity of water in the soil below 30 inches continued to decrease in the pine plantation; under the broomsedge it stayed practically the same, as it does throughout the whole year.

Whenever water is removed from the soil, storage space is made available for future rains. The above data show the superiority of a forested site over a herbaceous site in the storage of winter rains.

Table 1.--Inches of total water removed from soil beneath two cover conditions between April 1, 1952 and August 1, 1952

Soil depth	Young pine plantation	Old broomsedge field
Inches	Inches	Inches
0-15	1.38	1.23
15-30	1.45	0.75
30-42	1.13	0.34
42-54	1.82	0.25
54-66	2.00	0.05
0-66	7.78	2.62

Shortleaf Pine Seed Production

A study to determine the amount and quality of seed produced by shortleaf pine was installed in September 1953. The study involves two stands on the Calhoun Experimental Forest and one stand on the holdings of the Duke Power Company near Morganton, N. C.

The two stands on the Calhoun are both 40-year-old stands of average stocking with an average d.b.h. of 8.6 inches. The stand in North Carolina is a 65-year-old, heavily stocked stand with an average d.b.h. of 9.8 inches. Ten seed traps were placed in each stand and the seed was collected at weekly intervals. Cutting tests were made to determine the quality of the seed.

No seeds were found at any time in the traps in the North Carolina stand. We therefore assume that the stand produced very few seed or none at all. The stand itself is a dense stand with very close crowns. The trees average 84 feet in height and have very low live-crown ratios. This coupled with the fact that this was a poor seed year in general may explain why there was no seed.

The seed fall data for the two stands on the Calhoun are summarized in tables 2 and 3. Table 2 shows that the average number of sound seed per acre was 12,378, which was 55 percent of the total seed fall. Trousdell has shown that a minimum of 23,000 sound seeds per acre is required to regenerate loblolly pine to 90 percent stocking on a mineral soil seedbed. Assuming that shortleaf will require at least this amount it is apparent that this year's seed supply is inadequate to produce satisfactory stocking.

Table 2.--Shortleaf pine seed fall data on the Calhoun Experimental Forest 1953-54

	Stand 1	Stand 2	Average	Percent of total
Sound seeds per acre	14,748	10,008	12,378	55
Unsound seeds per acre	12,641	7,901	10,271	45

Table 3 shows that 82 percent of the total seed fall occurred during the month of November.

Table 3.--Percent seed fall by months

	October	November	December	January	February	March	Total
1953-54	4.8	82.1	9.5	3.6	-0-	-0-	100

Future plans call for a continuance of this study for several years so that the periodicity of cone crops can be determined.

Having both the standard screen-wire traps and the paper-board traps as manufactured by International Paper Company, the two types were paired to determine if there were a difference in their efficiencies. No significant difference was found between the number of seeds trapped in either type. The more economical paper-board traps will be used in the future if the study is expanded.

New Studies

Two new studies were started this quarter:

1. About 1,500 redbud seedlings were planted on various sites under different cover conditions to test their effect on surface soil properties. On all plots where there is satisfactory survival, soil characteristics will be analyzed to secure before treatment measurements. Check plots will be maintained at each planting site so that soil changes due to the present cover can be followed.

2. Plots were established on two types of surface soil (clay and sandy loam) beneath pine stands to see the effect of additions of hardwood litter on soil properties. This type of experiment should show, on a very condensed time scale, the effect of introducing hardwood species in a pine stand. On the plots established so far treatments are: (a) addition of hickory leaves, (b) addition of white oak leaves, (c) control. Material will be added to the plots each year at time of hardwood leaf fall. Measurements have been made on organic matter content of the surface soil and plots will be resampled in several years.

Publications

Soil temperatures in the South Carolina Piedmont, by G. E. Greene, Station Paper No. 29, Southeastern Forest Experiment Station. Temperatures are reported for the upper 6 feet of soil under four site conditions in the South Carolina Piedmont. The data were obtained as part of the procedure of determining soil moisture by the electrical resistance method at a barren site, a broomsedge field, an 11-year-old loblolly pine plantation and a 50-year-old shortleaf pine-hardwood stand.

General

The Piedmont Research Center staff took part in a two day management training session for personnel of the S. C. National Forests. W. A. Campbell, Pathology Division, also represented the Southeastern Station at this meeting.

The headquarters of the Center is now tied in with the National Forest radio network for fire control.

Haney spent 16 days on TRR inspecting forest holdings of Duke Power Company and Fairfield Forest Products in North and South Carolina.

APR 1958